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INTERSTATE CONFERENCE ON POLLUTION OF THE COLORADO RIVER

TECHNICAL DISCUSSION ON ACCOMPLISHMENTS AND FUTURE ACTIVITIES, HELD AT SANTA FE NEW MEXICO ON FEBRUARY 13-15, 1963

PUBLIC HEALTH SERVICE, DENVER, COLORADO

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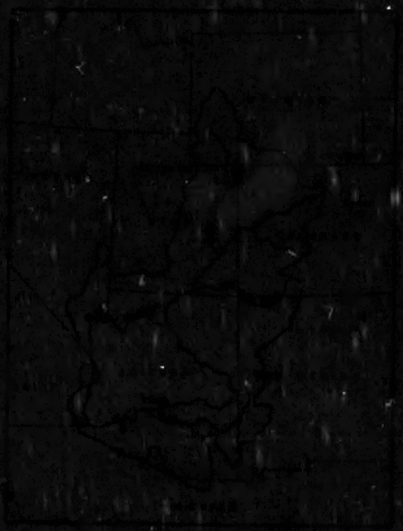

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COLORADO RIVER BASIN PROJECT ON WATER QUALITY CONTROL

June 3, 1960

INTRODUCTION

The purpose of this document is to present background information, the general objectives of the proposed Colorado River investigation, and to define the responsibilities and activities of the several PHS offices in carrying out the work.

The Colorado River Basin, draining 1/12 of the land area of the continental United States, is one of the last remaining frontiers in the economic development of this country. It is a region of vast potentiality with many mineral resources and fertile valleys. A great river system serves its various regions, many of which have deficient rainfall. The Basin's future development depends upon the maximum utilization of its water resources as regards both water quality and water quantity.

In this Basin are located many of the uranium sources of the Nation, and uranium mining and milling have created potential health problems, one of which is the pollution of surface and underground waters by wastes from the uranium milling industry. One of these areas, the Animas River, an interstate stream flowing from Colorado into New Mexico, became the center of an enforcement action under the provisions of Section 8 of Public Law 660, 84th Congress, because of the discharge to the river of radioactive wastes by a uranium processing plant at Durango, Colorado.

As a result of this action the several States of the Colorado River Basin felt a strong need for evaluating other possible situations of a similar nature and asked the Surgeon General to call a conference under Section 8, Public Law 660, 84th Congress, for that and other purposes concerning pollution of the waters of the Basin. The conference was held in Phoenix, Arizona, on January 13, 1960, and the conferees concluded that:

1) The material presented at the conference indicated that further investigation and study is needed to define the type of interstate pollution problems which may exist;

2) That such investigation and study should cover:

    a) Domestic and municipal wastes, (current and potential);

    b) wastes resulting from the harvesting and processing of the timber resources of the region, (current and potential);

    c) wastes from coal and oil shale deposit developments; (current and potential);

    d) industrial wastes, including wastes from food processing and similar industries, (current and potential);

e) deterioration of water quality by agricultural uses (including fertilizers and insecticides) and erosion;

f) pollution caused by radioactive wastes.

3) That such study should include the determination of specific pollutants and their concentration and include radioactive, chemical, biological, and microbiological studies, and an engineering analysis of the existing waste treatment facilities of the Basin and their effectiveness;

4) That such investigation and study should be directed toward methods of securing the best possible water quality for multiple water use, including domestic, industrial, agricultural, fish and wildlife, recreation, hydroelectric development, and the protection of public health;

5) That the initial stages of such study and investigation should be directed to determing the most critical and pressing problems in order that priorities may be established for developing data and securing needed remedial action on such problems;

6) That the Public Health Service would undertake, in cooperation with the State water pollution control agencies of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming, and other Federal agencies, the above-described pollution control study of the Colorado River and its tributaries within the limits of resources available to it; and,

7) That as soon as possible after the completion of this conference, the Public Health Service would present a detailed proposed plan of such study and investigation to the State and Federal agencies concerned for their review and comment; and that final plans of such study and investigation would be made available to all State and Federal agencies concerned.

OBJECTIVES

The project would fall into two broad categories having the following objectives:

1) A determination of the specific pollutants and their concentrations which now exist or which may reasonably be expected to exist in the immediate future resulting from various water uses within the Basin and the establishment of priorities for developing data on, and securing needed remedial action at the most critical and pressing problem areas. The most critical and pressing problem appears to result from pollution caused by the uranium mill operations in various sections of the Basin.

2) A determination of methods for securing the best possible water quality for multiple water use and the development of a comprehensive plan and program of water quality control for multiple

> water use within the Basin which can serve as a guide for the conference in progress and other enforcement actions which may be instituted subsequently, and to State and Federal agencies having an interest in the prevention and control of water quality degradation.

These, the two principal objectives, are, of course, closely interrelated and any activities directed toward the accomplishment of one will naturally complement the other. For practical reasons, the first objective should receive first consideration, as it is the one upon which implementation of the other depends. Moreover, work to accomplish the first objective can be initiated as soon as funds become available, at the latest in fiscal 1961, while the other objective will require more time to get underway since the work in that area will involve the development of working relations with other State and Federal agencies, the assemblage of existing data from all possible sources, plus special field studies to collect various types of water quality and related data. This sequence of operation is both logical and desirable, since the first phase of the total study will be directed to determining the most critical and pressing problems with a view to securing expenditious remedial action for those problems to be followed later by the long-range planning.

This project will require the fullest cooperation among all activities of the Public Health Service, a close working relationship with and among the several States, and an equally close working relationship with the several Federal agencies having responsibilities for various aspects of water resource development and use within the Basin.

RESPONSIBILITIES OF VARIOUS PUBLIC HEALTH SERVICE INTERESTS

It is recognized that the primary responsibility for water resource development and pollution control rests with the several States. In this instance, the States of the Basin requested the institution of a Federal enforcement action as provided for in Section 8 of the Federal Water Pollution Control Act (Public Law 660, 84th Congress). At the ensuing conference and in accordance with the authority of that Act, the conferees agreed that the PHS would, within the limits of resources available, undertake, in cooperation with the State water pollution control agencies of the seven States of the Basin and other Federal agencies, the investigation and study heretofore defined. Therefore, in accordance with its authority, the PHS will obtain the necessary funds and personnel to carry out these responsibilities.

CONFERENCE GROUP

The chairman of the conference, the conferees, and the Regional Program Director (WSPC) of Regions VII and IX will review and comment on the plans for the project in accordance with the conference agreement; review progress of the project at periodic intervals to assure coordination of the project with all interests concerned, and submit suggestions for guidance in the operation of the project.

COOPERATING AGENCIES

The conference agreement calls for participation in the project by the State and Federal agencies concerned with water resources conservation and development.

State Water Pollution Control Agencies

The State conferees will be the official State participant in the project. As such, each should provide liaison and coordination with other State water resource and related departments such as those having responsibilities for fish and game, State engineering, natural resources, and health; and procure reports, plans, studies, and other pertinent information developed by State agencies.

In addition, the State water pollution control agency is invited to participate in project operations by furnishing personnel and laboratory services to work with, and under, the general supervision of the Project Director. This participation is encouraged so as to enhance and develop local competencies in this field.

Federal Agencies

The several Federal agencies having responsibilities in water and land resource development are being invited to be cooperating agencies. These will include the Departments of Interior, Commerce, Labor, Agriculture, Defense, and Federal Power Commission. They should be kept informed of project progress and should be called upon to assist by providing basic data and other information within their respective competencies. Daily working relationships will be developed by the Project Director with the Basin Inter-Agency Committee to secure the cooperation of these Departments at the local level.

International Agencies

The Colorado River is an international stream and the International Boundary Commission concerned with Mexican relationships should be included as a cooperating agency. This will provide for proper recognition of interests outside U. S. borders. Primary contact will be made with the Mexican Desk, U. S. State Department, by the Technical Services Branch. Working relationships will be developed through the Regional Program Director, WSPC, Region VII (IW and BC headquarters are in El Paso, Texas).

METHOD OF OPERATION

The operating office of the project will be located at Denver, Colorado, with field stations established when and where the survey indicates. The staffing pattern will reflect the needs of the project and include engineers, biologists, chemists, hydrologists, economists, geologists, aides, etc.

The details for establishing and carrying out essential laboratory operations are being developed. Facilities for laboratory work will be centered at one place located in Salt Lake City, Utah. Special analyses, or where samples cannot readily be transported, may be made in the field, or at SEC, through the utilization of existing State or SEC laboratory facilities, respectively. While the laboratory operation will look to the Field Operations Section, SEC, for technical consultation, it will be under the administrative direction of the Project Director and responsive to the needs of the general field operations on the Colorado River Project. The Director, and technical personnel from the Field Operations Section, will function as a team in developing plans and procedures for specific phases of the project involving the laboratory.

The project will be initiated as soon as funds have been allocated. Limited field operations will be underway within three months after funds are made available. It is estimated that full-scale field and laboratory operations will be reached within one year after funds become available. It is expected that a report on the pollutional phases of interstate concern for the entire Basin can be completed within four years; however, studies will be directed at determining the most critical and pressing problem areas and individual reports on them completed as soon as field studies are made.

Interim operating progress statements to support budgetary requests and to keep the various agencies up-to-date on the progress of the work will be prepared quarterly with special reports prepared as required.

The field studies for the comprehensive plan and program of water quality control for the Basin should be completed in three years, and a report on this phase of the study should be completed by the end of the fourth year. One additional year should be allotted for unforeseen contingencies and the assembly and distribution of the final documents.

The results of the investigation and reports thereon will be used in connection with deliberations of the conferees and any additional conferences, hearings, or other enforcement action instituted as a result of disclosures made by the investigation.

These results and reports will also serve as the basis upon which conferees, hearing boards, and the Secretary will determine the remedial action to be taken to secure abatement and control of existing or threatened interstate pollution. Should court action become necessary to enforce abatement of interstate pollution, these results and reports will be used as Government evidence in support of the action. The plan for a comprehensive program will also provide guidelines for prevention and/or control of future pollution.

SUMMARY OF CONFERENCE
(SECOND SESSION)
POLLUTION OF INTERSTATE WATERS
# of the
COLORADO RIVER
AND ALL TRIBUTARIES
(COLORADO - UTAH - ARIZONA - NEVADA - CALIFORNIA - NEW MEXICO - WYOMING)

(Introduction and Attendance Roster omitted)

The Chairman of the Conference pointed out that:

1. Under the Federal Water Pollution Control Act (Public Law 660 - 84th Congress) pollution of interstate waters which endangers the health or welfare of persons in a State other than the one in which the discharge originates is subject to abatement under the procedures described in Section 8 of the Federal Act.

2. The first step of this procedure is the calling of a conference.

3. The purpose of the conference is to bring the States and the Public Health Service together to lay a basis for future action by all parties concerned and to give States and localities an opportunity to take remedial action which may be indicated under State and local law. The States have the primary responsibilities and rights in preventing and controlling water pollution.

4. This is the Second Session of the Conference in the matter of pollution of the interstate waters of the Colorado River and its tributaries, involving the States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming.

5. At the First Session, the Public Health Service agreed to undertake in cooperation with the States an investigation and study to define the type of interstate pollution problems that might exist in the interstate pollution problems that might exist in the interstate waters of the Colorado River and its tributaries, to include, among other things, a determination of specific pollutants and their concentration, methods of securing the best possible water quality for multiple use; the Public Health Service further agreed to present a detailed proposed plan of the study and investigation to the States and Federal agencies for review and comment.

The status of actions taken on the study and investigation as reported to the Second Session of the Conference follows:

1. The study and investigation has been designated as the Colorado River Basin Water Quality Control Project and will require about six years for completion. The staff has been organized, and out of a planned total personnel complement of 43 for the entire project, 14 are presently on duty at Project headquarters in Denver, and nine at the Project Laboratory in Salt Lake City, Utah.

2. The Laboratory is currently being constructed at an existing Federally-owned building at 1750 South Redwood Road, Salt Lake City, and construction should be completed by September, 1961.

3. Initial studies of the Project have been directed primarily toward the radiological aspects of basin water pollution. Findings in this field to date point to:

    a. Considerable reduction in environmental radiological contamination from uranium milling wastes.

    b. Due to the presence of toxic, non-radioactive chemicals, some of the uranium mill wastes discharged to streams are damaging to aquatic biota. This was especially noted in the San Miguel-Dolores River systems in 1960. It was also noted in 1958 in the Animas River, but since then, waste control measures installed at the Durango, Colorado, uranium mill have reduced pollution from this source with the result that in the 1960 surveys a definite gain in the downstream aquatic biota was noted.

    c. Crops at a small number of farms in certain defined areas in the upper basin have been found to contain radioactive contamination above acceptable levels.

    d. The radium content of dry washes receiving effluent from the uranium mills at Maybell, Colorado, and Mexican Hat, Utah, and of South Creek, which received effluent from the now-closed uranium mill at Monticello, Utah, were found to be sharply higher than general environmental levels.

    e. The necessity of developing means of preventing accidental releases of radioactive tailing liquors from uranium mill ponds, such as took place at Shiprock, New Mexico, late in 1960.

4. A substantial amount of work has been done in implementing one of the major objectives of the Project, the development of a comprehensive plan for long-range water quality management. Such work includes institution of studies on practically all characteristics of water quality, development of methods to be used for maintenance of satisfactory water quality, collection of basic data concerning water uses, and waste discharges in the Basin, pinpointing places of

such discharges, and the present and potential economic development of the Basin and its dependence on water supply. A detailed analysis of the U. S. Geological Survey data concerning the chemical quality of water in the Basin is under way, utilizing modern data processing methods.

5. Plans are reaching completion for the installation, maintenance, and operation of a radioactivity monitoring network of river waters over the entire Basin, comprising 25 to 30 sampling stations to be operated in cooperation with the State agencies to assay radiological content on a continuous basis. Field work in connection with establishment of the stations will begin in the near future.

The conferees agreed that the following matters should receive the greatest attention during the coming year:

1. Further general reduction in radioactive pollution of waters of the Basin so as to protect municipal and other water users both inside and outside the Basin.

2. Specific reduction in radioactive contamination of the waters in certain defined areas in the Upper Basin being used for irrigation, which is resulting in contamination of crops in these areas.

3. Continuing monitoring of the radioactive content of river sediments throughout the Basin.

4. Specific action directed toward reduction of the toxic effects of uranium mill wastes being discharged in the Basin.

5. Provisions for a safety factor to prevent accidental spills of wastes from uranium mills through the following steps:

    a. Development of criteria for the construction, maintenance, and operation of control facilities;

    b. Determination of compliance with such criteria;

    c. Development and initiation of an adequate alerting system to provide immediate notice to State and Federal agencies of accidental spills.

6. Detailed study to discover the causes and extent of quality deterioration in the waters of the Colorado River in the Yuma, Arizona, area, which has required the City to abandon use of a substantial quantity of such water as a source of its public supply, and immediate solution of the problem with full protection being accorded all municipal, agricultural, and industrial interests concerned.

7. Invitations to be extended by State agencies to all industries in the Basin who are interested in water quality to participate in future sessions of the Conference.

8. Solicitation from industries of all available data on Basin water quality and reports on what actions are being taken by them affecting it.

9. Furnishing to State agencies on a quarterly basis all available raw and analyzed data on all aspects of the Project being accumulated by PHS, either on a sub-basin or State basis, so that it can easily be extracted by the States.

The conferees agreed that the following reports will be prepared during the ensuing year and presented to the next session of the Conference:

1. Compliance with criteria developed for construction, maintenance, and operation of uranium mill waste control facilities, on a mill by mill basis; system utilized for alerting State and Federal agencies of any spills and how it is operating.

2. Location and extent of discharges of uranium mill and any other industrial wastes containing toxic non-radioactive chemicals which are damaging to aquatic biota and status of remedial action.

3. Extent of hazards from radioactive contamination of crops in the Upper Basin attributable to radioactive contamination of irrigation waters, and status of remedial action.

4. Extent of hazards from radioactive contamination of the dry washes at Maybell, Colorado, and Mexican Hat, Utah, and of South Creek, near Monticello, Utah, and the status of remedial action.

5. Status of solution of water supply problem at Yuma, Arizona.

6. Proposed methods for evaluating long-range effects of radioactive content of Basin deposits.

7. Pollution attributable to recreational boating use of Basin lakes.

8. Status of study on effects of pollution on oxygen levels in Basin waters.

9. Status of study on nitrate concentrations in underground waters in the Shiprock, New Mexico, area.

10. Progress report on development of long-term water quality management program for entire Basin.

11. Reports from industries participating in Conference of their activities in improving water quality.

12. Quality of water in Lake Mead and its suitability for use as domestic water supply.

13. Operational status of radioactivity water monitoring network.

14. Dilution requirements in the Animas and San Juan Rivers to protect water quality downstream.

SUMMARY OF CONFERENCE

(THIRD SESSION)

POLLUTION OF INTERSTATE WATERS
of the
COLORADO RIVER AND ITS TRIBUTARIES
(COLORADO-UTAH-ARIZONA-NEVADA-CALIFORNIA-NEW MEXICO-WYOMING)

(Introduction and Attendance Roster omitted)

The Chairman of the Conference pointed out that:

1. Under the Federal Water Pollution Control Act (33 U.S.C. 466 et seq.), pollution of interstate waters which endangers the health or welfare of persons in a State other than the one in which the discharge originates is subject to abatement under the procedure prescribed in section 8 of the Federal Act.

2. The first step of this procedure is the calling of a conference.

3. The purpose of the Conference is to bring the States and the U. S. Department of Health, Education, and Welfare together to review the situation, to lay a basis for future action by all parties concerned and to give states and localities an opportunity to take any indicated remedial action under state and local law as the states have the primary responsibility for preventing and controlling water pollution.

4. At the First Session of the Conference on the Colorado River and its tributaries, held on January 13, 1960, in the Phoenix Library Auditorium, Phoenix, Arizona, the Department of Health, Education, and Welfare agreed to undertake in cooperation with the states and other Federal agencies an investigation and study to define the type of interstate pollution problems that might exist in the interstate waters of the Colorado River and its tributaries, to include, among other things, a determination of specific pollutants and their concentration, and methods of securing the best possible water quality for multiple uses. The Department of Health, Education, and Welfare further agreed to present a detailed proposed plan of the study and investigation to the states and Federal agencies for review and comment.

5. At the Second Session of the Conference, held on May 11, 1961, at the Stardust Auditorium, Las Vegas, Nevada, the status of action taken on the study and investigation was reported.

At the Third Session of the Conference, the status of the investigation, study, and remedial action taken was reported as follows:

1. Staffing for the investigation and study project is essentially complete and so is the construction of the project laboratory located at Salt Lake City, Utah. Full scale laboratory operation has been inaugurated.

2. Cognizance was taken of the progress made as a result of efforts of the Public Health Service, the Atomic Energy Commission and industry, in the development of standards for construction of holding lagoons and dikes at uranium mills; on the development of a radium monitoring network and an alerting system for accidental spills from uranium mills.

3. A level of one micro-microcurie per liter or less of dissolved radium-226 prevails in the waters of the Basin except for the two exceptions mentioned in paragraph 7. Cognizance was also taken of the marked improvement of the water quality of the Animas River which, at the Colorado and New Mexico state line, has a level of dissolved radium-226 well below one micro-microcurie per liter.

4. Sediment surveys indicate a natural background level of 1.3 micro-microcuries of radium-226 per gram of sediment with variations from this average being slight. The survey indicates that the residual contamination of the Basin waters by radium is now very slight.

5. Bottom animal studies in the Animas River below the Vanadium Corporation of America's uranium mill at Durango, Colorado, showed large numbers of clean water organisms in all sections and indicated that the river in this area is now biologically normal. Bottom animal studies of the San Miguel River above the Union Carbide Nuclear Company installation at Uravan, Colorado, showed large numbers of clean water organisms. From below this mill to the mouth of the Dolores River, there was a drastic reduction in the number of these organisms. As a result of tests this is attributable primarily to the chemical toxicity of waste discharge by the Uravan mill, and not to their radioactivity.

6. Discharges from the Wellton-Mohawk Irrigation District contribute substantially to the deterioration of chemical quality of the Colorado River at Yuma. The City of Yuma has made a temporary arrangement for domestic water supply from the Yuma main canal, which is not a permanent solution to Yuma's domestic water supply problem. Silt from the All-American Canal desilting basin may be a major detriment to recreational uses of the Colorado River between Imperial Dam and Morelos Dam. Discharge of raw sewage from Yuma appears to have caused a substantial increase in coliform count below the outfall of that city.

7. Problems still exist with reference to certain areas, Montezuma Creek below Monticello, Utah, and the San Miguel-Dolores River system below Uravan, Colorado, which still have a level of dissolved radium-226 above one micro-microcurie per liter. Considerable effort is being made by the Atomic Energy Commission in the Monticello area and by Union Carbide Nuclear Company at Uravan to improve these situations,

and to bring them within the limits demonstrated to be reasonably feasible on the Colorado River. There are also indications of a relatively high level radium content of crops like alfalfa and grasses directly related to high levels of radium in top soil.

8. Progress has been made in developing the program for long-range water quality management. This includes:

   a. Completion of the first computer analysis of chemical water quality data.

   b. Development of basic demographic data in connection with an economic base study for the Basin.

   c. The substantial completion of the inventory of municipal and industrial water uses and waste discharges. + agriculture

   d. Planning studies on the Upper Main Stem of the Colorado River, the Green River and their sub-basins to provide basic data for development of comprehensive programs.

During the next year, the Colorado River Basin Project will conduct the following activities to:

1. Develop comprehensive programs for water quality control with emphasis on the upper main stem of the Colorado River and Green River Sub-Basins.

2. Collect and correlate required data and proceed with economic studies.

3. Evaluate results of crop surveys with reference to radiological content. meat

4. Conduct limited investigations into radium uptakes by stream biota, including fish.

5. Conduct exploratory investigations of pollution from recreational boating.

6. Investigate quality of water in Lake Mead and its suitability for domestic water supplies.

7. Conduct limited sampling of uranium mill effluents and environmental media to ascertain levels of lead-210 in view of its possible importance as a water contaminant and its low maximum permissible concentration.

In addition the following activities are planned for the project:

1. Further study and attempt to arrive at an acceptable to city of Yuma solution for the problem of salinity caused by discharges from the Wellton-Mohawk ~~reservoir.~~ District

2. Complete development of standards for construction of holding lagoons and dikes at uranium mills in cooperation with the Atomic Energy Commission and the State water pollution control agencies.
3. Complete development of an alerting system for accidental spills from uranium mills, in cooperation with the Atomic Energy Commission and the State water pollution control agencies.
4. Investigate the Monticello, Utah area for hazards from radioactive contamination.
5. Investigate further the radiological and toxic chemical condition of waters at Uravan, Colorado.
6. Complete the radium monitoring network and continue radium monitoring.
7. Continue on a limited basis monitoring of radiological content of sediments.

Activity: Crop Surveys (Reference Summary Item 3, page 8)

Purpose: Determination of radiological content of vegetables and crops grown on farms irrigated by river waters contaminated with uranium mill wastes, and comparison with crops and vegetables irrigated by uncontaminated waters.

Summary of Progress:

Five collections have been made from selected farms in the Upper Main-Stem Sub-Basin. These collections were made in August 1960, June, August, and September 1961, and September 1962. Samples of irrigation water, farm topsoil, fertilizers, vegetables, crops (primarily alfalfa), milk, and cow bones were collected.

The data from the first four crop surveys are presented in a report which is in the final stages of preparation. The following general conclusions were reached:

1. Significant amounts of radium-226 can be taken up by crops and vegetables grown on farms irrigated with water contaminated with uranium mill wastes.

2. Alfalfa samples collected from farms located downstream from uranium mining and milling activity contained radium-226 concentrations 10 times higher than did alfalfa collected from farms upstream of such activity.

3. Topsoil and irrigation waters showed radium concentrations three times higher on farms downstream from uranium activity as compared to topsoil and irrigation waters on upstream farms.

4. It was shown that phosphate-base fertilizers contained considerably more radium-226 than did non-phosphate base fertilizers.

5. Milk and cow bone samples obtained from farms located downstream from uranium mills exhibited radium concentrations 18 times and 13 times higher, respectively, than milk and cow bone samples from upstream farms.

Future Plans:

Data from the fifth crop collection will be analyzed and compared to the earlier data.

Activity: Investigation of quality of water in Lake Mead and its suitability for domestic water supplies.

Purpose: The objectives of this activity are the determination of chemical, biological and radiological parameters of Lake Mead water quality for suitability as a public water supply.

Summary of Progress:

The U. S. Geological Survey, U. S. Fish and Wildlife Service, Bureau of Reclamation, and the States of Arizona and Nevada have been contacted concerning applicable data which may be available. Analysis of water quality data from U. S. Geological Survey publications has been initiated. Knowledge of the sparcity of available data indicates that a large scale investigation of Lake Mead is necessary to adequately meet the request of the Conferees.

Future Plans:

Analysis will continue as data is received. It is anticipated that a report will be issued containing the results of this review.

A plan and proposal for a large scale investigation of Lake Mead will be developed and consideration will be given to the inclusion of such a study within the scope of the overall Project. Such a large-scale undertaking would be integrated into the overall Project plan.

Activity: Conduct of exploratory investigations of pollution from recreational boating. (Reference Summary Item 5, page 8)

Purpose: The objective of this activity is the assessment of pollution from recreational boating on Lakes Mead and Havasu.

Summary of Progress:

Information on pollutional effects of recreational boating has been obtained from various sources, primarily the Sanitary Engineering Center in Cincinnati. Review of this data indicates that additional field data will be necessary to evaluate fully this problem. Accordingly, a short-term field survey will be conducted during April 1963 on Lakes Mead and Havasu to obtain further information.

Future Plans:

Analysis will be made of the data and information obtained. A report containing the findings and recommendations will be prepared. Future activities in this area of interest will be conducted if so indicated by these exploratory investigations.

Activity: Determination of lead-210 in uranium mill effluents and environmental media. (Reference Summary Item 7, top of page 9)

Purpose: Conduct limited sampling of uranium mill effluents and environmental media to ascertain levels of lead-210 in view of its possible importance as a water contaminant and its low maximum permissible concentration.

MPC -33

Summary of Progress:

Uranium mill effluents and sediments were taken in the vicinity of a number of uranium mills. Nine effluent samples were taken from five uranium mills (VCA at Durango, Colorado; UCN at Uravan, Colorado; UCN at Maybell, Colorado; UCN at Rifle, Colorado; Texas-Zinc at Mexican Hat, Utah). These are being analyzed at the present for lead-210. (Radium determinations on the same samples have been completed.) Preliminary results on four effluent samples from two mills seem to show that lead-210 concentrations vary greatly with the mills and range from 4 to 20 times the radium concentrations.

Future Plans:

Analyses for lead-210 will be completed in time for a presentation of results in April 1963. No additional work is planned in this fiscal year.

If the results of the analyses indicate further work is needed, the investigation would be extended to include the pollutional effects of lead-210 on water and crops.

Activity: Evaluation of the chemical toxicity of uranium mill and other industrial wastes to aquatic life. (Reference Summary Item 5, page 9)

Purpose: To obtain additional information on effluents previously found toxic to fish. Previous data on this subject was reported at the Third Conference on the Matter of Pollution of Interstate Waters of the Colorado and Its Tributaries in May of 1962. To evaluate the toxicity of newly discovered effluents in order to assess their possible effects on aquatic life in receiving streams.

Summary of Progress:

Laboratory bioassays were conducted on effluents from six uranium mills, two metal processing mills, and a gilsonite refinery. Some of these effluents were highly toxic to fish and are damaging aquatic life in receiving waters.

A summary of these investigations is attached.

Future Plans:

Bioassays will be repeated on some of the more toxic effluents to note any improvements or changes which may occur. Additional information such as their toxicity to different species of fish and the effect of certain water quality characteristics on toxicity will be evaluated in order to more completely assess the possible effects on aquatic life. As new effluents are discovered, bioassays will be conducted to determine their toxicity.

notify States to take corrective action

Bioassay Studies

Toxicity of Uranium Mill Effluents, Other Industrial Wastes, and Mine Drainage Streams to Fish

During the fall of 1962, bioassays were conducted on effluents from six uranium mills, two metal concentrating mills and a gilsonite refinery, and on drainage streams from abandoned mines. The routine bioassay procedure as given in the 11th Edition of Standard Methods was used. In most of the bioassays, the test fish were 3-inch fingerling rainbow trout. However, as some effluents enter warmer non-trout waters, comparative toxicity information was desired for a warm-water species of fish. Consequently, comparative toxicity tests were made using 3-inch goldfish which are comparable to some of the more tolerant warm-water species. Conditioned Salt Lake City tap water was used for dilution. Bioassays were conducted in a constant temperature room at 60°F.

Uranium Mill Effluents

The results of bioassays on uranium mill effluents are shown in Table 1. Twenty-four, 48 and 96-hour TLm (median tolerance limit--the concentration that produces 50% fish mortality) values are shown. Also, given are the estimated dilution requirements for the effluent (1) to produce 50% fish mortality and (2) for protection of aquatic life. As precise effluent flows were not known, these values are computed on a per unit of effluent basis. In other words, one cfs of effluent would require the computed values of stream flow to produce the indicated result. The values for safety to aquatic life are computed on the basis of an application factor of ten.

A comparison of the toxicity of some of these effluent samples with similar samples collected during March 1962 is shown in Table 2. All of the effluents shown in this table directly enter streams within the Colorado Basin.

The sample of effluent from the Texas-Zinc mill at Mexican Hat collected in October was somewhat less toxic than the sample collected in March. Dilution requirements, however, still exceed anticipated low flows in the San Juan River. It may be expected that aquatic life would be affected to some degree in the San Juan River below this outfall.

The sample of Uravan Plant 5 effluent collected in October was of about the same toxicity as the sample collected in March. Dilution requirements for this effluent far exceed low flows in the San Miguel River. Biological studies conducted in August 1962 show that the bottom fauna in the San Miguel River and Dolores River below this outfall is drastically affected.

The sample of Rifle's main plant effluent collected in October was considerably more toxic than the previous sample collected in March. The dilution requirements are such that this effluent could have an effect on aquatic life in the Colorado River during low flow periods.

The sample of Durango's main plant effluent collected in October was somewhat more toxic than the March sample but would still be considered to have a relatively low toxicity. On the basis of dilution requirements, it would not be expected that this effluent would have a detrimental effect on aquatic life in the Animas River.

The sample of effluent collected from the Standard Uranium Corporation at Silverton during November 1962 was relatively non-toxic. Other biological studies, however, show a considerable reduction in bottom animals below this outfall. It is possible that this effluent fluctuates in toxicity and the grab sample collected was not a representative sample. Effluents from this plant need further investigation.

Other Industrial Wastes

A 5-day composite sample was collected from the Gilsonite Refining Co., Grand Junction in August 1962 Grab samples of three effluents from the Idarado Mill at Telluride, Colorado, and an effluent from the Camp Bird Mill at Camp Bird, Colorado, were collected in November 1962. Also, collected at this time were samples from streams containing considerable quantities of mine drainage waters. The results of these bioassays are shown in Table 3.

The sample of Gilsonite effluent collected in August was highly toxic to fish (TLm - 1.3%) although somewhat less toxic than the previous sample collected in March (TLm - 0.75%). Dilution requirements of this effluent remain at levels which could possibly affect aquatic life in the Colorado River during low flows.

An effluent from the Idarado Mill which enters Marshall Creek at the mill site was highly toxic to fish. Dilution requirements for this effluent far exceed stream flows in the San Miguel River. Other biological studies conducted in October showed a practically complete absence of bottom animals in the San Miguel River from this outfall downstream to the South Fork. The stream was apparently affected to some degree for a number of miles below this confluence. The other effluent from this mill which enters the San Miguel, the tailings overflow, was of relatively low toxicity.

The sample of effluent from the tailings pond at Camp Bird showed no toxicity. However, the mill had not been in operation for several weeks prior to collecting this sample. The poor biological condition of Canyon Creek below this mill indicates that some previous condition has severely affected aquatic life. Further investigation in this area is needed.

Mine Drainage

Water from abandoned mines enters Red Mountain Creek above Ouray, Colorado. These waters are highly acid and apparently contain large amounts of iron and other metals. The rocks on the bottom of the streams are cemented together and are covered with heavy deposits of an orange precipitate. Bioassays were conducted on several of the streams containing mine drainage. While these mine drainage streams were toxic to fish, it could mostly be attributed to pH effect. When pH was raised by dilution to levels expected to support aquatic life (6-7), no fish mortality occurred.

In order to try and determine the reason for the poor biological condition of Canyon Creek, a bioassay was conducted on a sample of water collected near the mouth at Ouray. However, no toxicity was found in this sample.

Comparative Toxicity to Trout and Goldfish

The results of comparative toxicity tests with trout and goldfish are shown in Table 4. The bioassays were conducted under identical conditions on effluents which were collected in March 1962.

Goldfish were more tolerant of all of these effluents than trout, in most cases by a factor of about 2. It is possible that where only warm-water species are of concern and bioassay results are based on trout, the application factor could be reduced from 10 to 5. It will be necessary to conduct bioassays with other warm-water species before this can be verified.

Table 1

Toxicity of Uranium and Mill Effluents

Effluent	Date Collected	TLm - % Concentration			Est. Dilution Requirements per cfs of Effluent	
		24-hr.	48-hr.	96-hr.	50% Fish Mortality	Safety to Aquatic Life
Union Carbide Mill - Maybell, Colorado:						
Effluent from 3rd settling pond	9-27-62	3.8	3.8	3.8	25	250
From effluent pipe - before settling pond	9-27-62	2.9	2.9	2.7	36	360
Texas-Zinc Mill - Mexican Hat, Utah:						
Main effluent to river	10- 3-62	0.66	0.66	0.66	150	1,500
Seepage from ponds	10- 3-62	-	No toxicity		-	-
Union Carbide Mill - Uravan, Colorado:						
Plant 5 effluent	8-7-62	0.27	0.27	0.26	384	3,840
Plant 5 effluent	10-5-62	0.39	0.39	0.39	255	2,550
Yellow cake tails	8-7-62	2.7	2.7	2.7	36	360
Yellow cake tails	10-5-62	4.3	4.3	4.3	22	220
Union Carbide Mill - Rifle, Colorado:						
East weir effluent	10-6-62	-	No toxicity		-	-
Main effluent - west weir	10-6-62	1.3	1.0	1.0	99	990
Vanadium Corp. of America Mill Durango, Colorado:						
Main plant effluent	10-4-62	32	32	18	4.6	46
Standard Uranium Corp. Mill - Silverton, Colorado:						
Main effluent to river	11-14-62	75	75	75	-	10

Table 2

Comparative Toxicity of Uranium Mill Effluents
March - October
1962

	March, 1962		October, 1962	
Effluent	96-hr. TLm % Effluent	Recommended Dilution per cfs	96-hr. TLm % Effluent	Recommended Dilution per cfs
Texas-Zinc Effluent	0.45	2,200	0.66	1,500
Uravan Plant 5	0.40	2,500	0.39	2,550
Uravan Yellow Cake	1.3	730	4.3	220
Rifle Main Plant	4.1	230	1.0	990
Durango Main Plant	29	30	18	46

use actual flows for mills

Table 3

Toxicity of Other Industrial Wastes and Mine Drainage

Effluent	Date Collected	TLm - % Concentration			Est. Dilution Requirements per cfs of Effluent	
		24-hr.	48 hr.	96-hr.	50% Fish Mortality	Safety to Aquatic Life
Gilsonite Refinery - Grand Jctn., Colo.:						
Overflow from lagoons composite	8/13-17/62	1.5	1.3	1.3	76	760
Idarado Mill - Telluride, Colo.:						
Effluent to river at mill site	10/11/62	0.75	0.75	0.75	132	1,320
From pipe to tailings pond	10/11/62	6.4	6.4	6.4	15	150
Overflow from tailings pond	10/11/62	56	32	32	2.1	21
Camp Bird Mill - Camp Bird, Colo.:						
Sample from tailings pond	10/9/62	-	No toxicity		-	-
Mine Drainage Streams:						
E.Fork Red Mtn. Creek - above mill site	10/ 9/62	13	12.5	12.5	7	70
Uncompahgre River - above Ouray, Colo.	10/10/62	75	75	75	-	10
Canyon Creek at Mouth	10/10/62	-	No toxicity		-	-

Table 4

Comparative Toxicity of Effluents to Trout and Goldfish

March 1962

	TLm - % Effluent					
	Trout			Goldfish		
Effluent	24-hr.	48-hr.	96-hr.	24-hr.	48-hr.	96-hr.
Texas-Zinc Effluent	0.45	0.45	0.45	0.75	0.75	0.75
Uravan Plant 5	0.41	0.40	0.40	0.80	0.75	0.75
Rifle Main Plant	4.4	4.1	4.1	10.0	8.9	7.5
Shiprock - Organic Raffinate	0.15	0.15	0.15	0.72	0.72	0.72
Vanadium Corp. of Amer. - Organic Raffinate	0.48	0.45	0.44	1.6	1.3	0.75
Gilsonite Effluent	0.75	0.75	0.75	1.5	1.4	1.4

Activity: Radium Uptake by Stream Biota (Reference Summary Item 4, pg. 8)

Purpose: To determine the concentration of radium and possibly other nuclides in various kinds of stream biota including fish, bottom animals, and algae.

Summary of Progress:

This study has just recently been initiated. Approximately 20 fish samples have been collected from the Upper Green River for analysis. Approximately 70 bottom animal samples from the upper and lower Colorado River and several contributaries are also available for analysis. No samples have been analyzed to date due to the laboratory backlog of other samples.

Future Plans:

Arrangements have been made with the Utah Fish and Game Department to collect fish in the Colorado River and tributaries in Utah during the spring and early summer of 1963. Fish will also be collected from Lake Mead during this period.

It is expected that fish and other aquatic biota collections will be made in the upper Colorado and tributaries in Colorado during fiscal year 1964. Samples will be analyzed for radium and other nuclides as the laboratory work load permits.

Activity: Yuma, Arizona Vicinity - Salinity Problem Study (Reference Summary Item 1, page 9)

Purpose: The sampling network, begun in June 1961 and following a short-term field study by the Project, was established to provide additional needed water quality data to fully assess the sudden quality degradation of the water supply for the City of Yuma, Arizona obtained from the Colorado River. Soon after the initiation of this network, it became evident that the data obtained would also be of use in evaluation of the water quality of the Colorado River being delivered to Mexico ~~in accordance with treaty obligations~~. This water is utilized in Mexico for extensive irrigation and also for domestic water supplies.

Summary of Progress: In June 1962 the Project determined that data obtained from the sampling network was sufficient to evaluate the salinity situation in the area. The sampling network was therefore terminated at the end of June 1962 with the exception of one station. Daily sampling by the International Boundary and Water Commission is continuing at the Northerly U.S.-Mexican Border as a surveillance measure. Collection of essential background information, analyses of water quality data, and preparation of a report covering all aspects of the Yuma vicinity situation, are at an advance stage and will be completed by April 1963. Certain comments resulting from the analysis of data to date are given below:

conditions in river

1. Mean monthly concentrations and loadings for the principal stations of the sampling network are shown in Table 1.

2. The water quality of the Colorado River at Yuma, Arizona is consistently poorer than at the northerly U.S.-Mexico Border. Figure 1, giving mean monthly concentrations of total dissolved solids during the period of sampling for the three Colorado River mainstem stations illustrates this fact.

3. While discharges to the Colorado River via Pilot Knob and Yuma Main Canal Wasteways result in higher loads of total dissolved solids crossing the northerly U.S.-Mexico Border, as shown in Figure 2, these flows are primarily responsible for the reduction of concentration of dissolved solids in the river from Yuma to the U.S.-Mexico Border.

4. Mean monthly total dissolved solids concentrations in the Colorado River above the confluence of the Gila River ranged from 860 mg/l to 1081 mg/l. These concentrations at Yuma varied from 2231 mg/l to 3009 mg/l, representing an average increase of 170% in the River reach.

5. Mean monthly total dissolved solids concentrations in the Colorado River at the Northerly U.S.-Mexico Border ranged from 1162 mg/l to 2505 mg/l, representing an average increase of about 75% in the reach from above the confluence of the Gila River to the Northerly Border. During periods of significant flow from the two principal wasteways mentioned above, total dissolved solids concentrations at the Northerly Border ranged from 1162 mg/l to 1320 mg/l.

6. Relative mean percentages, for the period of sampling, of the major ions at the three main-stem stations, indicating a buildup of Na and Cl ions, are shown in the following table.

TABLE II

Relative Percentage of Weight of Major Ions

Station	Cations			Anions		
	Ca	Mg	Na	HCO_3	SO_4	Cl
Y-1A Colo. R. above Gila R.	36.1	12.7	51.2	27.5	50.8	21.7
Y-5 Colo. R. at Yuma	25.5	10.9	63.6	12.8	32.8	54.4
Y-6 Colo. R. at N.US-Mex Border	29.3	11.2	59.5	18.8	38.3	42.9

Future Plans: Continuous sampling for both chemical and radiological analyses at the Northerly U.S.-Mexico Border will continue for an indefinite period to provide the Project with current data on the water quality of the Colorado River at this point.

The report of water quality in the Yuma Arizona Vicinity will be completed by April 1963.

TABLE I

Selected Stations of the Yuma, Arizona Vicinity Sampling Network
Mean Monthly Concentrations (mg/1) and Loadings (Thousand lbs/day)
June 1961 to June 1962

Month		Station	Mean Discharge, cfs.	Total Dis. Solids		Sulfate		Chloride	
				mg/1	10^3#/day	mg/1	10^3#/day	mg/1	10^3#/day
June 1961	Y-1A	Colorado River **above confluence** of Gila R.	876	954	4504	331	1563	131	618
	Y-8	Mouth of Gila River	248	5835	7800	965	1290	2572	3438
	Y-6	Colorado River at Northerly US-Mex Border	3005	1162	18821	336	5442	254	4114
July 1961	Y-1A		693	920	3436	355	1326	122	456
	Y-8		267	6058	8718	966	1390	2473	3559
	Y-6		3732	1200	24138	352	7081	246	4948
Aug. 1961	Y-1A		658	874	3100	309	1096	131	465
	Y-8		324	5566	9720	936	1634	2154	3762
	Y-6		3486	1222	22961	368	6914	299	5618
Sept. 1961	Y-1A		419	994	2245	341	770	149	336
	Y-8		336	5669	10267	974	1764	2316	4194
	Y-6		1832	1676	16550	448	4424	520	5135
Oct. 1961	Y-1A		332	1018	1822	358	641	158	283
	Y-8		359	5805	11233	949	1836	2361	4568
	Y-6		949	2505	12813	530	2711	902	4614
Nov. 1961	Y-1A		387	1003	2092	361	753	167	348
	Y-8		313	5710	9633	670	1130	2487	4196
	Y-6		971	2314	12111	502	2627	809	4234
Dec. 1961	Y-1A		369	1079	2146	355	706	180	358
	Y-8		258	4078	5671	777	1080	1706	2372
	Y-5	Colorado River at Yuma, Arizona	749	2373	9580	514	2075	833	3363
	Y-6		1229	2102	13924	480	3180	674	4465
Jan. 1962	Y-1A		358	974	1879	351	677	160	309
	Y-8		420	4981	11276	907	2053	2083	4715
	Y-5		891	2892	13889	604	2901	1085	5211
	Y-6		2435	1721	22587	447	5867	518	6799
Feb. 1962	Y-1A		288	1081	1678	376	584	204	317
	Y-8		408	4897	10769	901	1981	2105	4629
	Y-5		812	3009	13169	637	2788	1177	5151
	Y-6		1297	2156	15072	515	3600	728	5089

TABLE I (Continued)
Selected Stations of the Yuma, Arizona Vicinity Sampling Network
Mean Monthly Concentrations (mg/1) and Loadings (Thousand lbs/day)
June 1961 to June 1962

Month	Station	Mean Discharge, cfs*	Total Dis. Solids		Sulfate		Chlorides	
			mg/1	10^3#/day	mg/1	10^3#/day	mg/1	10^3#/day
March 1962	Y-1A	612	861	2840	333	1098	129	426
	Y-8	359	4858	9400	885	1712	2064	3994
	Y-5	1070	2231	12867	508	2930	794	4579
	Y-6	3546	1229	23490	361	6900	340	6498
April 1962	Y-1A	771	860	3574	348	1446	130	540
	Y-8	383	5100	10528	903	1874	2180	4500
	Y-5	1128	2300	15224	530	3508	831	5500
	Y-6	3468	1320	24674	374	6991	356	6654
May 1962	Y-1A	541	920	2683	357	1041	142	414
	Y-8	405	5070	11068	912	1991	2150	4693
	Y-5	1115	2540	15265	588	3534	930	5589
	Y-6	2030	1720	18820	410	4486	544	5952
June 1962	Y-1A	522	920	2588	355	999	140	394
	Y-8	388	4990	10436	903	1888	2080	4350
	Y-5	1045	2520	14194	545	3070	909	5120
	Y-6	2598	1500	21005	407	5699	422	5909

*For days of sample collection only.

Fig. 1

YUMA, ARIZONA VICINITY SAMPLING NETWORK
Mean Monthly Total Dissolved Solids mg/l
June 1961 - June 1962

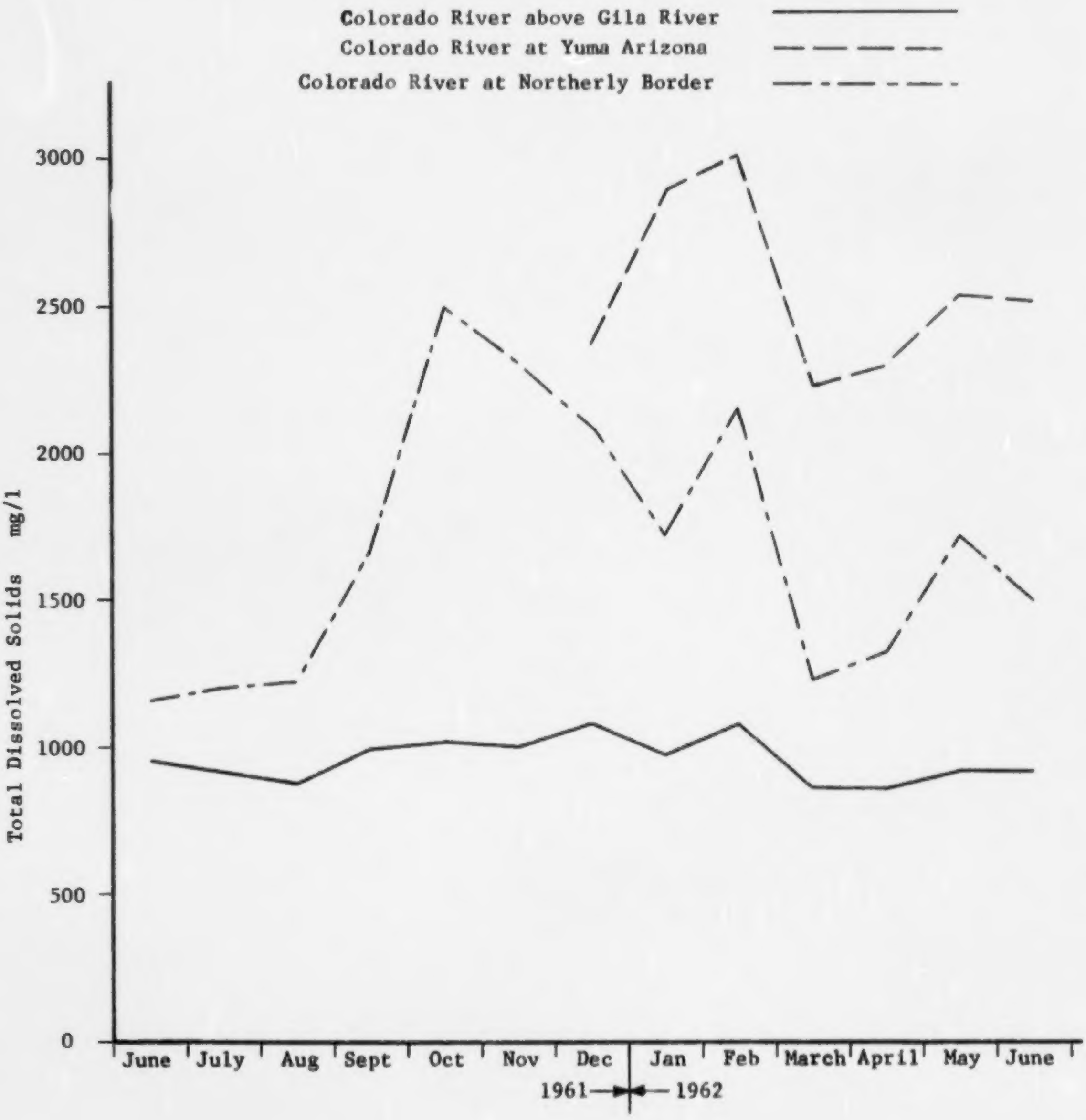
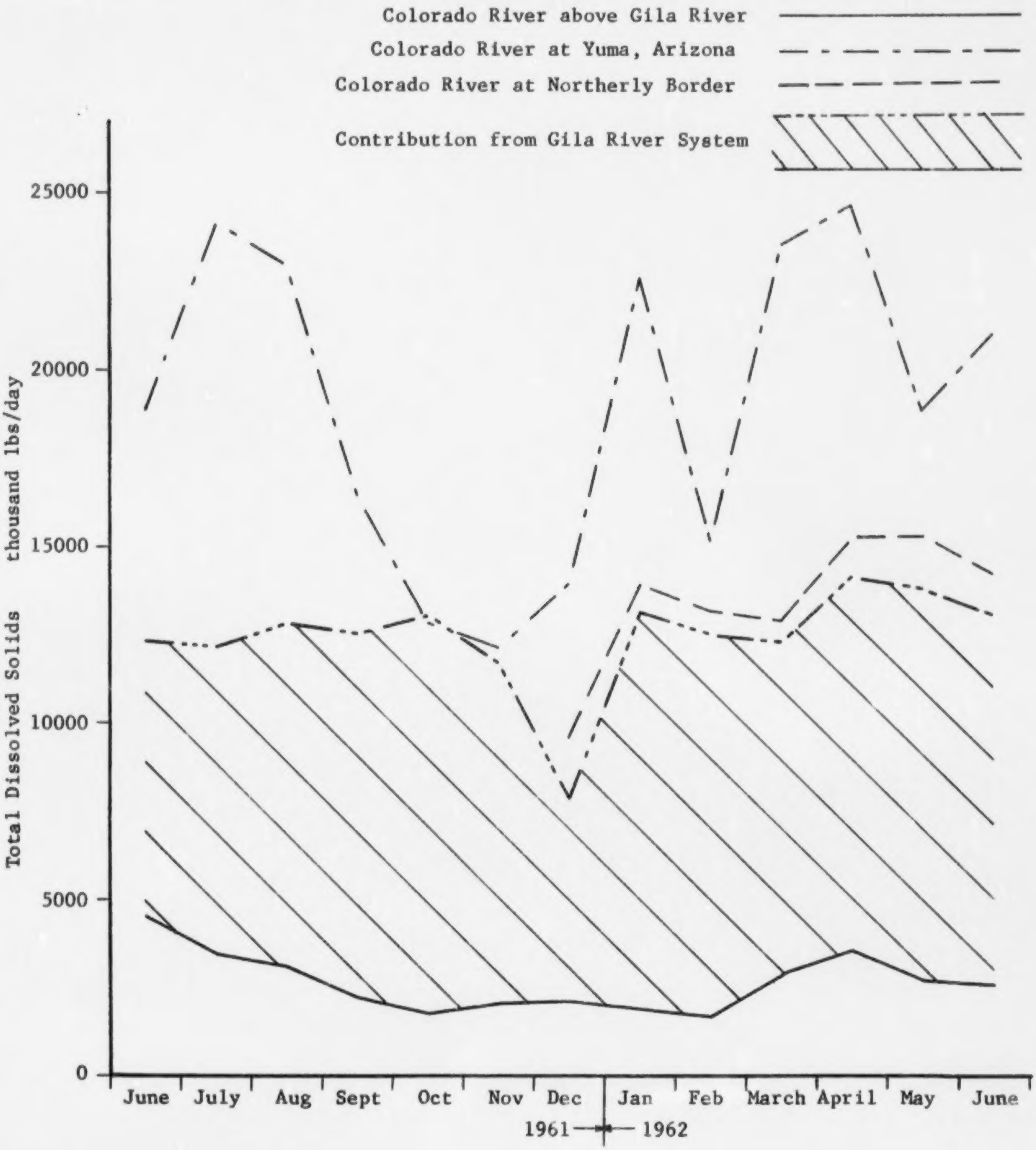


Fig. 2

YUMA, ARIZONA VICINITY SAMPLING NETWORK

Mean Monthly Total Dissolved Solids thousand lbs/day
June 1961 - June 1962

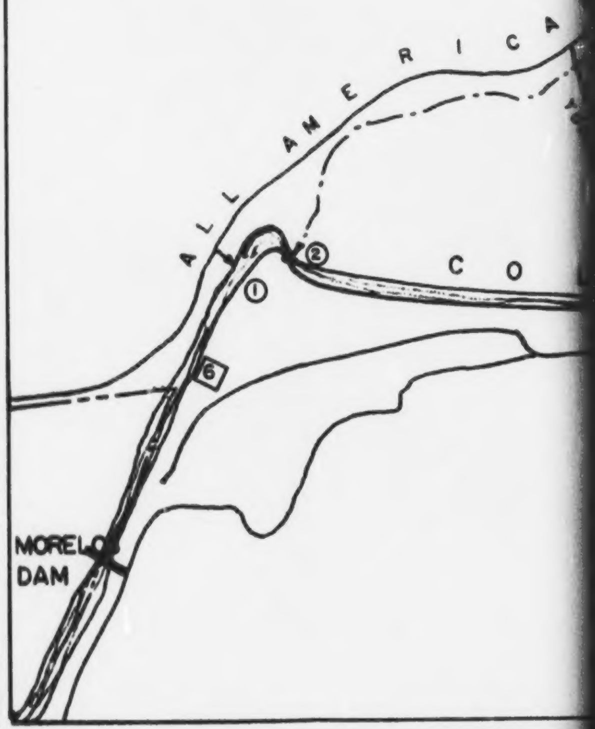


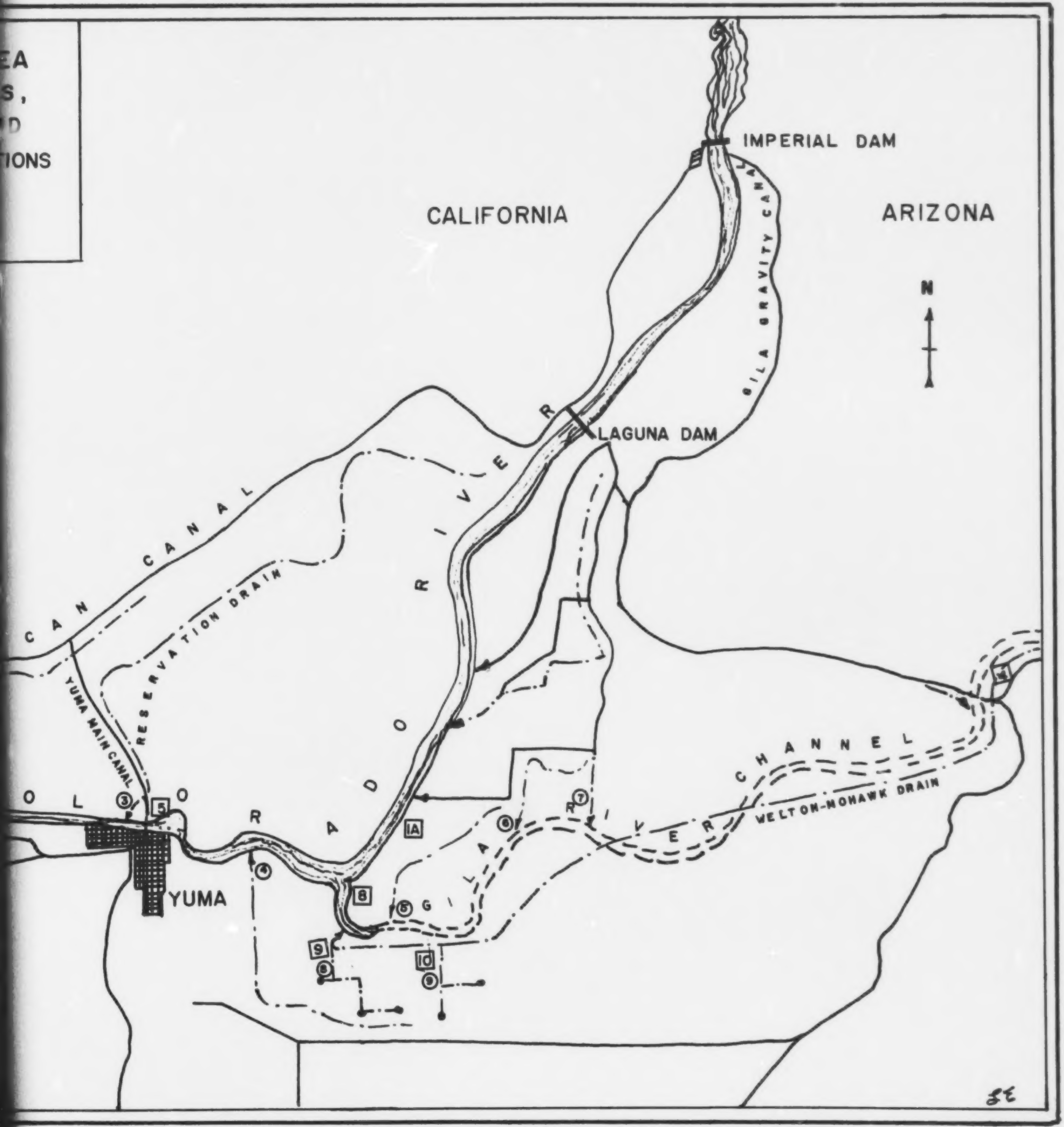
YUMA, ARIZONA AREA
MAJOR DELIVERY CANALS, DRAINS, WASTEWAYS AND PHS CRP SAMPLING STATIONS

APRIL - 1962

KEY

———	MAIN CANALS
—·—·—	DRAIN &/OR WASTEWAY
—— — — ——	INTERNATIONAL BOUNDARY
→	DISCHARGE TO RIVER
☐	PHS CRBWQCP SAMPLING STATION
○	DRAIN OR WASTEWAY
①	PILOT KNOB WASTEWAY
②	DRAIN 8B
③	YUMA MAIN CANAL WASTEWAY
④	SOUTH GILA DRAIN NO 2
⑤	BRUCE CHURCH DRAIN
⑥	BRUCE CHURCH WASTEWAY
⑦	NORTH GILA MAIN CANAL WASTEWAY
⑧	NO 1 PUMP DRAIN (WEST)
⑨	NO 2 PUMP DRAIN (EAST)
1A	Y - 1A COLORADO RIVER ABOVE GILA R.
4	Y - 4 WELLTON-MOHAWK DRAIN →
5	Y - 5 COLORADO RIVER AT YUMA
6	Y - 6 COLORADO RIVER AT NORTHERLY U.S. - MEXICO BOUNDARY
8	Y - 8 GILA RIVER AT MOUTH
9	Y - 9 NO. 1 PUMP DRAIN
10	Y - 10 NO. 2 PUMP DRAIN

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LAGUNA DAM
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RESERVATION DRAIN
YUMA MAIN CANAL
OLORADO RIVER
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Activity: Dike Construction Criteria (Reference Summary Item 2, page 9)

Purpose: Development, in conjunction with the Atomic Energy Commission, of standards for construction of holding lagoons and dikes at uranium mills.

Summary of Progress:

Design and construction criteria were drafted by the Atomic Energy Commission, discussed with Public Health Service personnel, and modified on the basis of comments made at the meeting. In connection with development of these criteria, the Project Director accompanied AEC personnel on a series of visits to uranium mills in the Basin. The criteria were further modified by the AEC and will be distributed to the uranium mills and Conferees in the near future for review and comment. When completed, these criteria will be used as an Atomic Energy Commission Licensing Guide.

Future Plans:

None

Activity: Uranium Mill Spill Alerting System (Reference Summary Item 3, page 9)

Purpose: This system provides prompt notification of downstream water users in the event of accidental release of radioactive and chemically toxic uranium milling wastes.

Summary of Progress:

The following method of notification of all parties concerned has been developed:

a. The uranium mill involved immediately notifies the Atomic Energy Commission, Division of Compliance, Denver.

b. The AEC notifies:

1. The ~~Health~~ WPC Departments of the States involved.

2. Colorado River Basin Project Headquarters.

3. Other AEC offices as required.

c. It is recommended that immediately upon reciept of such notification, the State Health Department take the following actions:

1. Notify water users downstream of the mill that an accidental release of wastes has occurred, and advice as to appropriate protective measures.

2. Notify other appropriate State agencies and officials.

d. The Colorado River Project Office will take action to see that the appropriate officials within DHEW are notified.

Activity: Monticello Surveys (Reference Summary Item 4, page 9)

Purpose: To evaluate the radiological pollutional effects of residual contamination from the AEC uranium mill at Monticello, Utah. This mill permanently ceased operation in 1959. Sizable tailings residues were left on either side of Montezuma Creek, which flows through the mill property.

Summary of Progress:

The initial sampling in this area was carried out during the first Basinwide sediment survey of August 1960. At that time samples were taken from South and Montezuma Creeks.

Following this initial sampling, more detailed sampling was carried out in November of 1961, and April, June and October of 1962. Accompanying figures show the sampling locations for the more detailed surveys. Table I presents a description of all sampling locations.

Tables II and III present a summary of all data obtained to date. A brief discussion follows:

TABLE I

Description of Sampling Locations

Station	Description
MC-1	Montezuma Creek 1/4 mile above Monticello Sewage Treatment Plant
1.5	Montezuma Creek at Utah Highway 47 Bridge above mill
2*	Montezuma Creek just above AEC mill
3	Montezuma Creek on mill property
4	Montezuma Creek at downstream edge of mill property
5	Montezuma Creek 1 mile below mill
6	Montezuma Creek at Sorenson Farm
6W	Sorenson Well
7.5	Montezuma Creek 25 miles below mill
8	Montezuma Creek 30 miles below mill
9	Montezuma Creek 50 miles below mill

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* Samples from both upper and lower bridge. See figure following for details.

Activity: Monticello Surveys (continued)

1. It is seen from the water data presented in Table II that excluding stations 1 and 1.5, which can be considered as background stations, the radium concentrations average 5.2 μμc/l for the remaining stations. This is about twice the current MPC value of 3.0 μμc/l for radium-226.

2. These non-background stations show an average radium concentration of 8.5 μμc/l for the November 1961 survey compared to 4.1 μμc/l from the other three surveys.

3. From Table III, again excluding stations 1 and 1.5, the radium content from all remaining sediments collected averages 133 μμc/gm. October 1962 data has not been received up to the present time.

Future Plans:

A follow-up survey of the study area is planned for spring of 1963. This survey will evaluate the effects of recent covering and seeding of the residual tailings by the AEC.

Run SO_4 and other chemical

TABLE II
MONTICELLO SURVEYS
Dissolved Radium in Water

Station	Dissolved Radium-226 (μμc/l) Collection Time Nov. 1961	April 1962	June 1962	October 1962
1	-	0.03	-	-
1.5	-	-	-	0.08
2	0.12	0.04	-	0.11
3	2.74	2.73	-	1.25
4	12.1	7.1	-	2.16
5	-	-	-	6.50
6	27	5.1	4.6	6.6
6W *	4.6	4.4	4.4	-
7	8.6	5.6	8.3	7.2
7.5	-	1.2	-	3.5
8	0.71	-	-	-

*Sample collected 8-13-60 had a radium content of 3.8μμc/l.

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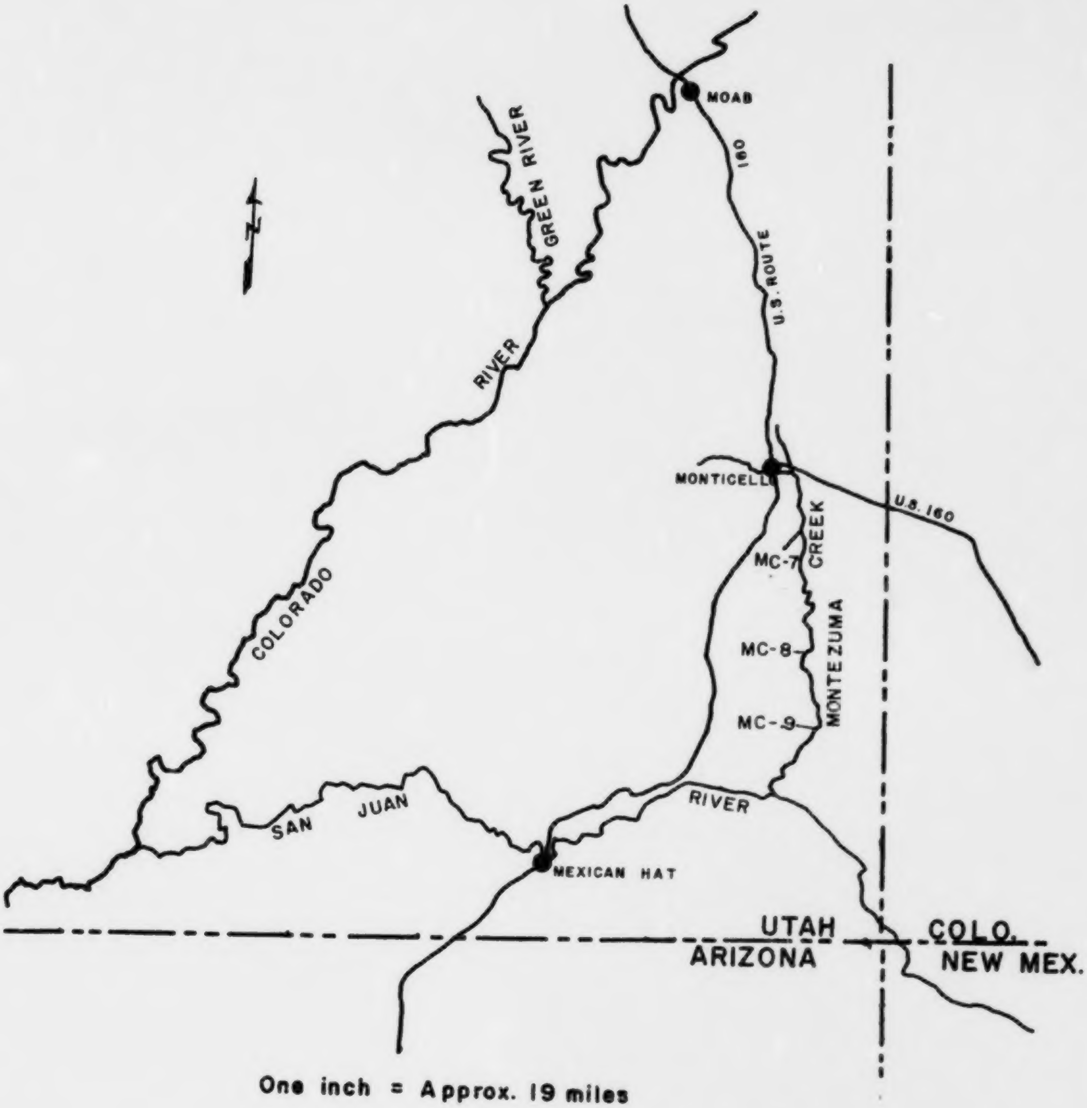
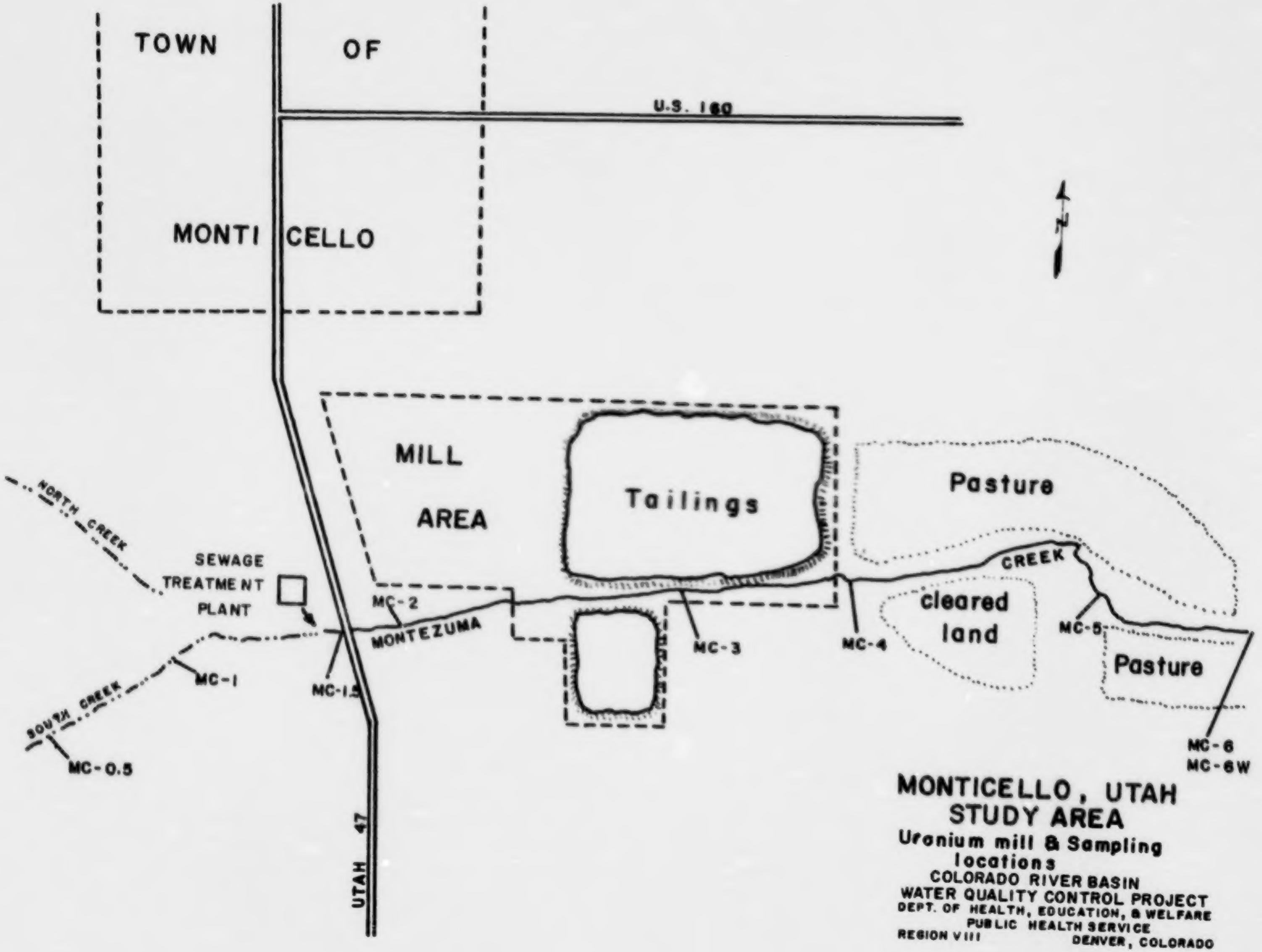
TABLE III
MONTICELLO SURVEYS
Radium in Sediments

Station	Radium-226 (μμc/gm) Nov. 1961	April 1962	June 1962	October 1962
1.0	1.1	2.3	-	
1.5	-	1.6	-	
2	46	12.1	7.8, 3.7	
3	320	230	-	
4	430	185	-	
5	265	182	-	
6	202	160	67	
7	33	88	52	
7.5	-	3.3	-	
8	0.80	-	-	
9	0.40	-	-	


N
MOAB
GREEN RIVER
160
U.S. ROUTE
RIVER
COLORADO
MONTICELLO
U.S. 160
CREEK
MONTEZUMA
MC-7
MC-8
MC-9
SAN JUAN
RIVER
MEXICAN HAT
UTAH
ARIZONA
COLO.
NEW MEX.
One inch = Approx. 19 miles

MONTICELLO, UTAH
AREA STUDY
COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO



MONTICELLO, UTAH
STUDY AREA
Uranium mill & Sampling locations
COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

TOWN OF MONTICELLO
U.S. 160
N
MILL AREA
Tailings
Pasture
CREEK
cleared land
Pasture
NORTH CREEK
SEWAGE TREATMENT PLANT
MC-2
MONTEZUMA
MC-3
MC-4
MC-5
MC-6
MC-6W
MC-1
MC-1.5
SOUTH CREEK
MC-0.5
UTAH 47

Activity: Uravan Surveys (Reference Summary Item 5, page 9)

Purpose: To assess the chemical, biological, and radiological pollutional effects of discharge of wastes from the Union Carbide Nuclear Co. uranium mill at Uravan.

Summary of Progress:

To date three surveys have been carried out in the Uravan area. The first detailed survey was carried out in August 1960, the results of which have been reported in Project Report No. 4. The second detailed survey was conducted during the period March 3-17, 1962 and the results of this survey have already been presented and compared to the August 1960 data. A third brief sampling survey was carried out in August 1962. The data from this survey are presented below.

These data, when compared to the August 1960 data, indicate that the dissolved radium content of San Miguel and Dolores River waters has slightly decreased while the radium content of bottom sediments have materially increased. However, these data, when compared to the March 1962 survey show that radium levels in the later survey were significantly higher both in waters and sediments.

August 1962 Uravan Area Samples

Station No.	Description	Radium-226 Water μμc/l	Radium-226 Sediment μμc/gm
SM-1	San Miguel River below highway bridge just above Uravan, Colorado	0.40	5.95
SM-2	San Miguel River immediately below Uravan mill	1.61	9.91
D-3	Dolores River at Neptune Bridge	1.05	5.64
D-4	Dolores River 13.4 miles above Gateway	1.93	--
D-5	Dolores River at Gateway	2.41	7.40
D-6	Dolores River near mouth	2.69	--

It should be pointed out that the radium values for these two river systems remain as the highest encountered in the entire Basin.

Future Plans:

Additional brief sampling will continue in this area.

Radium - 226 Content in Dolores-San Miguel River Waters and Sediments
Uravan Area

Location	August, 1960 Water ($\mu\mu c/l$)	August, 1960 Sediment ($\mu\mu c/g$)	March, 1962 Water ($\mu\mu c/l$)	March, 1962 Sediment ($\mu\mu c/g$)	August, 1962 Water ($\mu\mu c/l$)	August, 1962 Sediment ($\mu\mu c/g$)
Dolores R. imm. above San Miguel River	3.4	$\leq$ 6.0	0.63	1.0	-	-
San Miguel R. above Naturita	---	---	0.04	0.9	-	-
San Miguel R. above Vancorum	---	---	0.04	---	-	-
San Miguel R. below Vancorum	---	---	0.17	3.8	-	-
San Miguel R. imm. above Uravan	1.0	4.2	0.20	2.2	0.40	6.0
San Miguel R. imm. below Uravan	2.4	18.	0.52	8.0	1.6	9.9
San Miguel R. at mouth	2.0	19.	0.26	5.5	---	---
Dolores R. at Neptune Bridge	---	---	1.0	3.9	1.1	5.6
Dolores R. 1/2 distance from Uravan to Gateway	2.3	4.8	0.70	---	---	---
Dolores R. at Gateway	5.5	1.4	0.87	2.8	2.4	7.4
Dolores R. 1/2 distance from Gateway to mouth	---	---	1.0	---	---	---
Dolores R. at mouth	3.9	8.2	0.88	---	2.7	---

Activity: Dolores-San Miguel Rivers Water Quality Study (Reference Summary Item 5, page 9)

Purpose: The objectives of this study were to obtain detailed information on chemical, radiological and biological water quality of the Dolores-San Miguel River system and to differentiate between natural and man-made sources of pollution affecting water quality.

Summary of Progress:

A two-week survey of the Dolores and San Miguel Rivers was carried out during March 1962. The area covered during the two-week survey period is shown on the following location map. In addition to the sampling stations indicated, four waste discharges from the Union Carbide Nuclear Company uranium mill at Uravan, Colorado were sampled.

Radiological results from the survey are in the preliminary stages of analysis. In view of the enclosed data, there appears to be a rise in radium-226 concentration in the vicinity of each uranium milling operation; the Vanadium Corporation of America upgrading uranium mill located below Naturita, Colorado, and the Union Carbide Nuclear Company uranium mill located at Uravan, Colorado, and the inactive Union Carbide Nuclear Company upgrading uranium mill at Slick Rock, Colorado.

Comparison of the March 1962 data with data obtained in a survey conducted in this area in August 1960[1] shows similar radium-226 concentrations in the vicinity of the Slick Rock, Colorado uranium mill. Data comparisons in the area of the Uravan, Colorado uranium mill show an approximate 80% decrease in the concentration of Radium-226 below the mill during the March 1962 survey.

Data from station D-11 (Gateway, Colorado) on the Dolores River from the March 1962 survey show an average radium-226 concentration of 0.87 μμc/l compared to an average radium-226 concentration of 5.5 μμc/l found in August 1960.

A moderate amount of the radium-226 present in the Dolores River is attributable to tributary creeks originating in uranium mining and ore reserve areas. A concentration as high as 10 μμc/l was found in one of these tributaries. Leaching of river bottom sediments below millsites may also contribute substantially to the radium-226 concentrations in these rivers.

1/ "Stream Surveys in Vicinity of Uranium Mills III - Area of Uravan, Slick Rock, and Gateway, Colorado - August 1960," USDHEW, PHS, Colorado River Basin Project, September 1961.

Activity: Dolores-San Miguel Rivers Water Quality Study (continued)

Most of the chemical data from the survey have been received and partially evaluated and are presented here in graphic form. Concentrations and loadings of total dissolved solids and individual ions are shown in the accompanying graphs.

Total dissolved solids in the Dolores main-stem show a moderate increase downstream from Dove Creek, Colorado until the river enters Paradox Valley where subsurface salt deposits are dissolved and enter the river. Total dissolved solids are increased from 662 mg/l to 4273 mg/l and from 282 to 2131 thousand pounds per day in the stretch of river from Bedrock, Colorado to the confluence of the Dolores and San Miguel Rivers. In this same stretch, chloride concentration increases nearly twenty-eight times from 106 mg/l to 2218 mg/l and sodium concentration increases nearly fourteen times from 89 mg/l to 1340 mg/l. Other constituents did not change substantially through this area, attributing nearly all of the total dissolved solids change to sodium and chloride increases.

Total dissolved solids in the San Miguel River show increases from Naturita Creek and the vicinity of the Vanadium Corporation of America and Union Carbide Nuclear Company milling areas. Much of the increase in each milling area and especially the Uravan area is due to sulfate addition.

Below the confluence of the Dolores and San Miguel Rivers decrease of constituent concentrations and loadings may indicate precipitation of material induced by reaction of constituents contained in the two waters.

Future Plans:

Further evaluation of all data will be made and a report will be prepared for issuance in FY 1964. A short-term study will be conducted during the second half of FY 1963 to evaluate the river after the new waste disposal seepage ponds have been constructed by Union Carbide Nuclear Corporation at the Uravan mill.

Activity: Dolores-San Miguel Rivers Water Quality Study (continued)

Dates	Stream Station Numbers	Location	Ra-226 μμc/l
3/12-23/62	SM-1	San Miguel River above Norwood, Colorado	0.55
	SM-4	San Miguel River just above Dry Creek	0.04
	SM-6	San Miguel River 1.7 miles below VCA mill	0.17
	SM-8	San Miguel R. above Uravan, Colorado	0.20
	SM-9	San Miguel R. below Uravan, Colorado	0.52
	SM-10	San Miguel R. at mouth	0.26
	D-1	Dolores R. above Dove Creek, Colorado	0.15
	D-2	Dolores R. above Slick Rock, Colorado	0.26
	D-3	Dolores R. below Slick Rock, Colorado	0.97
	D-4	LaSal Creek above mouth	1.9
	D-15	Dolores River at Bedrock, Colorado	0.71
	D-5	Dolores R. just above confl. of San Miguel R.	0.63
	D-7	Mesa Creek at mouth	10.
	D-11	Dolores R. at Gateway, Colorado	0.87
	D-14	Dolores R. near mouth	0.88

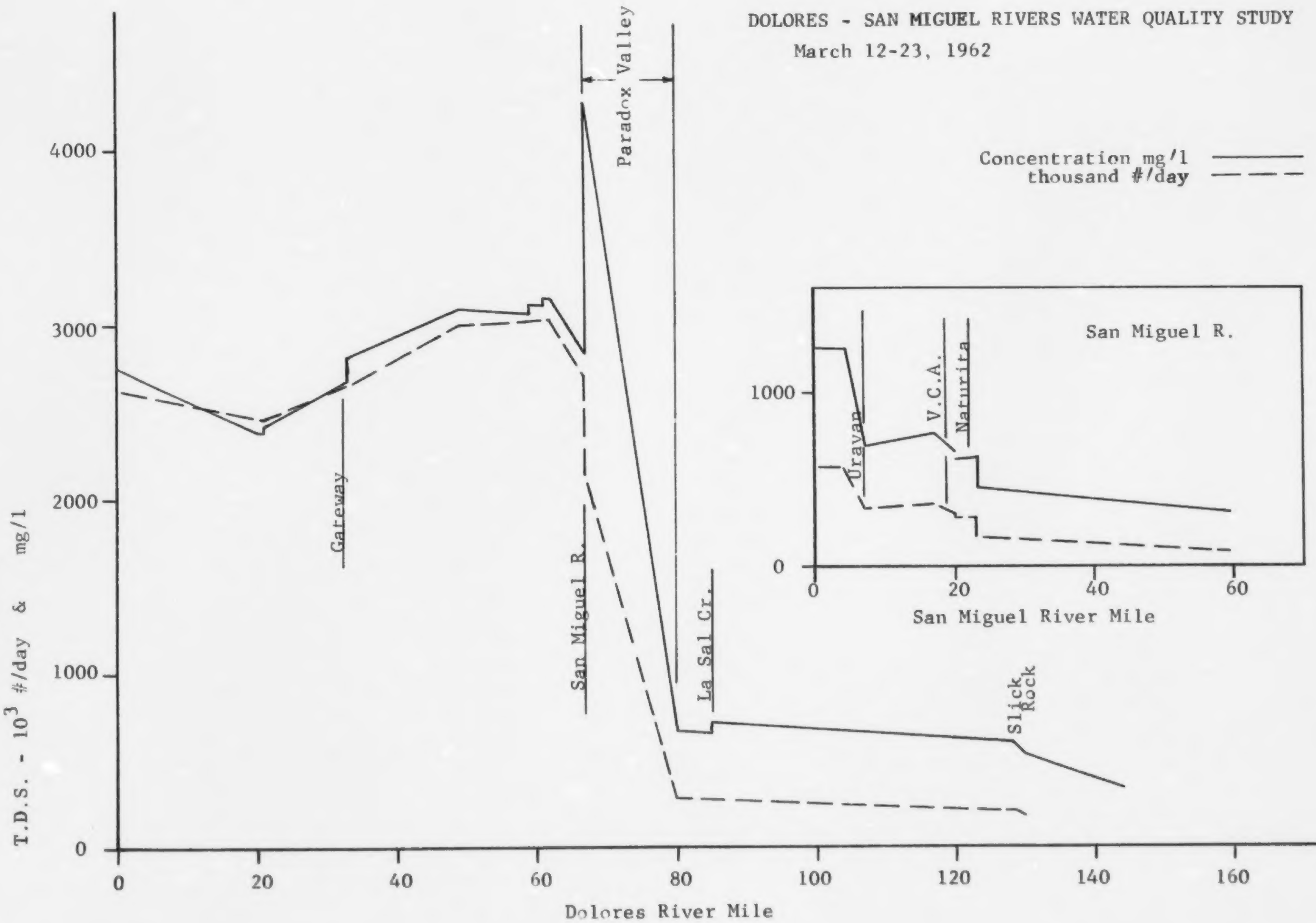
Dates	Uranium Mill Effluent Station Numbers	Location	Ra-226 μμc/l
3/12-23/62	M-1	East mill drain	3.8
	M-2	Yellow cake tailings liquor	38.3
	M-4	Plant No. 5 pond overflow	68.9
	M-5	West mill drain ditch	12.6

Dolores-San Miguel River Study
Total Dissolved Solids Concentrations & Loadings

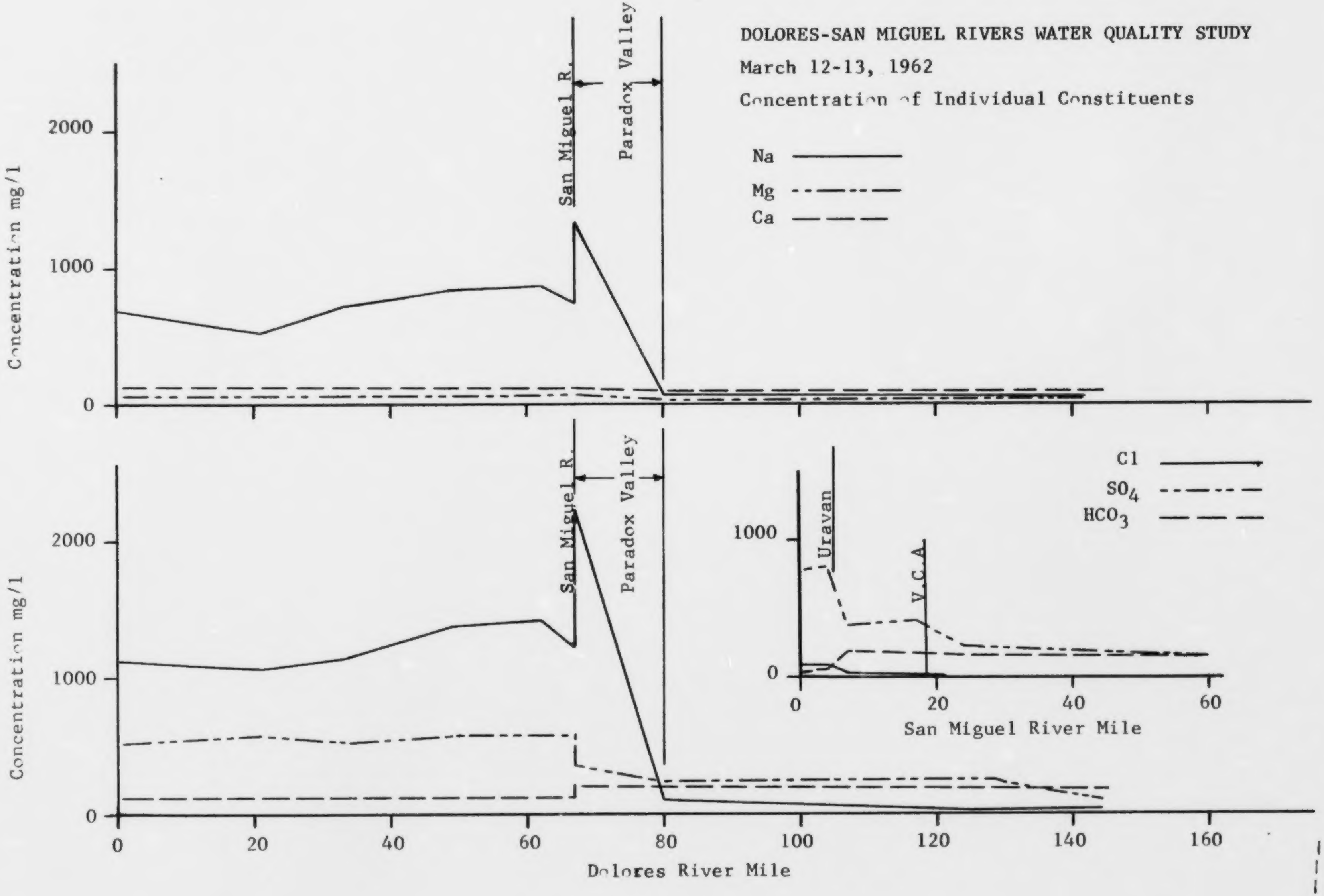
Station Number	Station Description	River Mile	T.D.S. mg/1	T.D.S. 10^3 #/day
D-1	Dolores R. above Dove Creek	144	346	--
D-2	Dolores R. above Slick Rock U mill	130	522	192.0
D-3	Dolores R. below Slick Rock U mill	128	595	218.0
D-15	Dolores R. at Bedrock	80	662	282.0
D-5	Dolores R. immed. upstream of confl. with San Miguel R.	67	4273	2131.0
D-6	Dolores R. at Neptune Bridge	62	3159	3032.0
D-11	Dolores R. Sta. in Gateway, Colo.	33	2668	2647.0
D-13	Dolores R. immed. above Beaver Cr.	21	2409	2454.0
D-14	Dolores R. near mouth (Colo.R.M.)	1023	2627	2762.0
SM-1	San Miguel R. above Norwood	59	319	86.0
SM-4	San Miguel R. immed. upstream of Dry Creek	20	606	280.0
SM-6	San Miguel R. 1.7 miles below VCA mill	17	777	363.0
SM-8	San Miguel River above Uravan	7	696	329.0
SM-9	San Miguel R. below Uravan	4	1260	577.0
SM-10	San Miguel R. at mouth (Dolores RM)	67	1245	570.0

Individual Constituent Concentrations

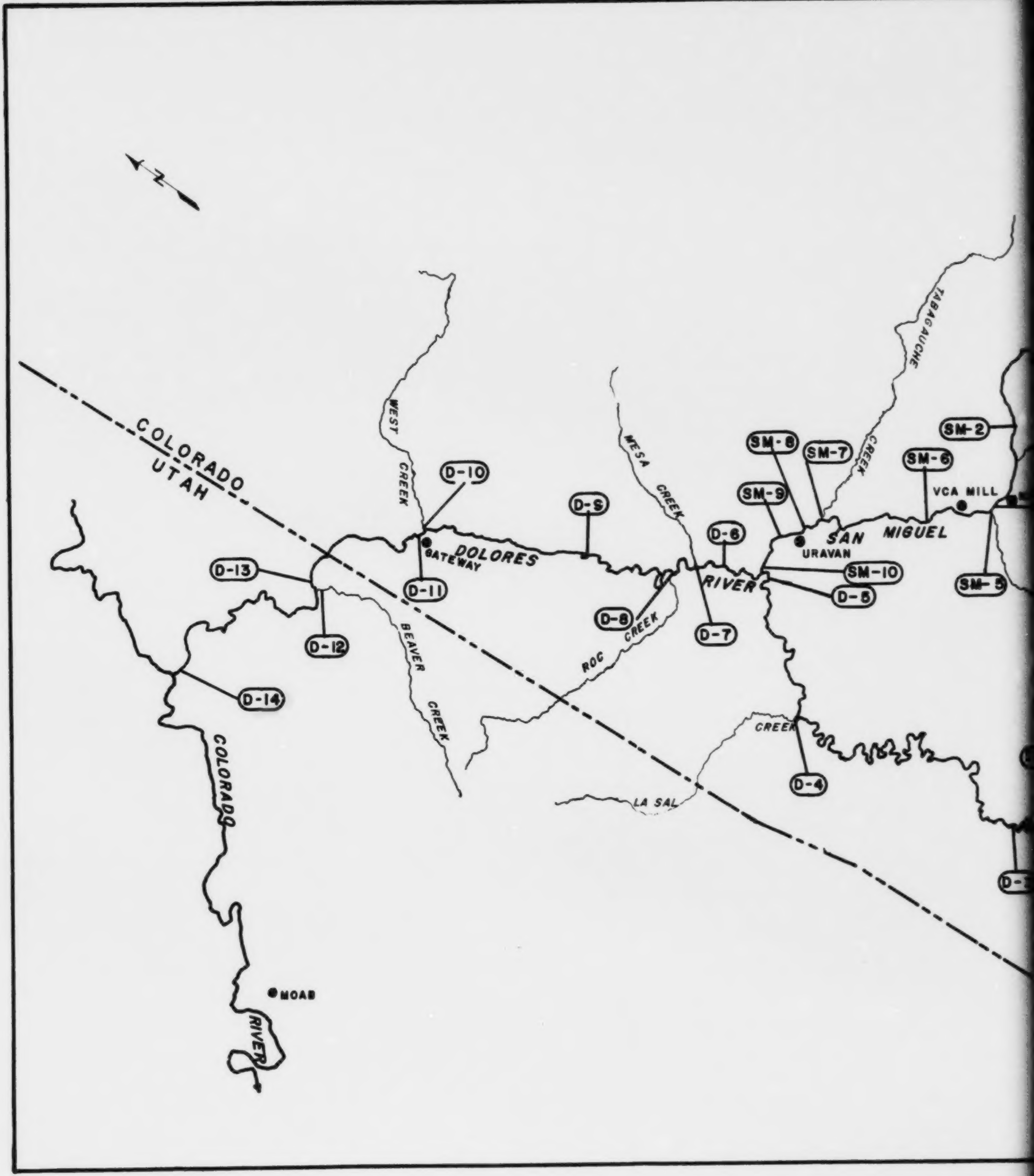
Station Number	Concentrations in mg/1					
	Ca^{++}	Mg^{++}	Na^{+}	HCO_3^-	$SO_4^=$	Cl^-
D-1	79	20	19	184	111	21
D-2	92	30	49	179	221	37
D-3	99	33	55	196	270	37
D-15	94	31	89	195	240	106
D-5	118	69	1340	200	353	2218
D-6	131	72	852	115	582	1415
D-11	125	72	716	127	508	1143
D-13	127	63	518	131	539	1060
D-14	133	68	689	122	521	1115
SM-1	82.3	20.7	5.9	135	140	1.6
SM-4	87	47.2	38.8	186	325	13
SM-6	121	57	58	187	428	17
SM-8	114	53	45	193	384	16
SM-9	134	79	98	62	814	95
SM-10	137	84.7	103	39	792	99

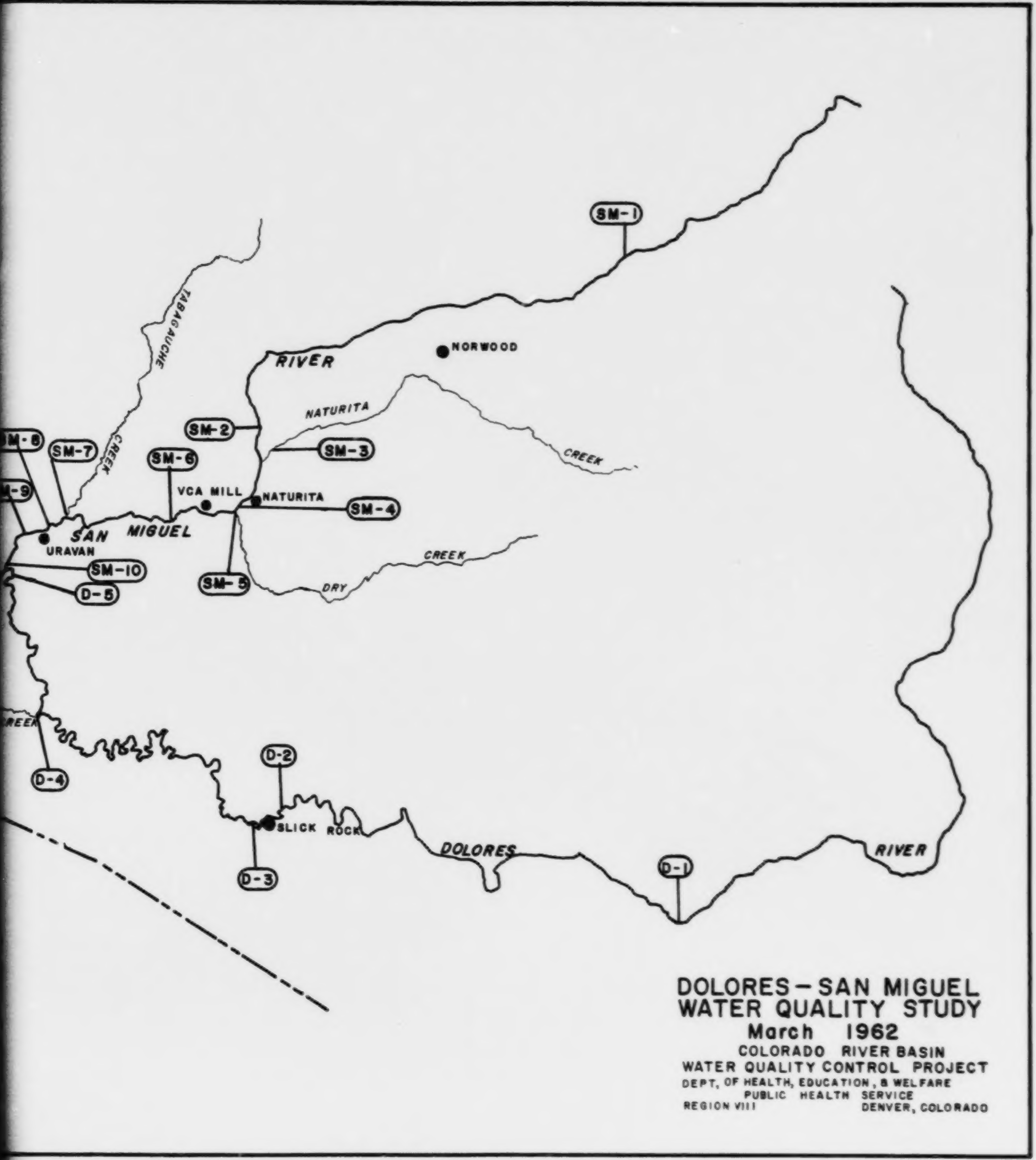


DOLORES - SAN MIGUEL RIVERS WATER QUALITY STUDY
March 12-23, 1962



DOLORES-SAN MIGUEL RIVERS WATER QUALITY STUDY
March 12-13, 1962
Concentration of Individual Constituents


N
COLORADO
UTAH
WEST CREEK
D-10
D-9
GATEWAY
DOLORES
D-13
D-11
D-12
BEAVER CREEK
D-14
COLORADO
RIVER
MOAB
MESA CREEK
D-6
D-8
ROC CREEK
RIVER
D-7
TABAGAUCHE CREEK
SM-8
SM-7
SM-9
SM-6
SM-2
VCA MILL
SAN MIGUEL
URAVAN
SM-10
D-5
SM-5
CREEK
D-4
LA SAL


SM-1
RIVER
NORWOOD
NATURITA
CREEK
TABAGAUCHE
CREEK
SM-2
SM-3
M-8
SM-7
SM-6
VCA MILL
NATURITA
SM-4
M-9
SAN
MIGUEL
URAVAN
SM-10
D-5
SM-5
CREEK
DRY
REEK
D-4
D-2
SLICK
ROCK
D-3
DOLORES
D-1
RIVER

DOLORES – SAN MIGUEL
WATER QUALITY STUDY
March 1962
COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
DEPT, OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

Activity: Follow-up Bottom Animal Study, Dolores-San Miguel Rivers

Purpose: To further evaluate biological conditions in the San Miguel and Dolores Rivers below the uranium mill at Uravan, Colorado.

Summary of Progress:

An additional bottom animal survey as part of a continuing study since August, 1960 was made during low water, high temperature conditions in August 1962. Other results for this program activity were reported at the Third Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries in May, 1962. Bottom animal populations continue to be drastically curtailed by effluents from the Uravan mill.

A report on the August 1962 study is attached.

Future Plans:

At the present time, waste disposal ponds are being developed at the Uravan plant. Follow-up studies to evaluate anticipated improvements in the stream resulting from these treatment measures will be made in the spring of 1963.

Bottom Animal Studies

Dolores-San Miguel Rivers

August 1962

Bottom animal studies were conducted at selected stations on the Dolores-San Miguel Rivers during August 1962. The main purpose of this study was to further evaluate biological conditions in the San Miguel and Dolores Rivers below the Union Carbide uranium mill at Uravan, Colorado. Previous studies in March 1962 had found bottom animals greatly depleted in the reach of the San Miguel River from the Uravan mill to the Dolores River and in the Dolores all the way to its confluence with the Colorado River. A previous study conducted in August 1960 had shown the Dolores River above the San Miguel to have very limited flow at this time. The study also showed a fair bottom animal population at San Miguel and Dolores River stations below the Uravan mill. As this was greatly different from conditions found in March 1962, it was believed that an additional study should be conducted in August during low flow, high temperature conditions.

One square yard bottom animal samples were collected by the same procedure as used in previous surveys at the stations described in Table 1. Location of these sampling stations is given in the general area map included within a preceding item for the Dolores-San Miguel Rivers Water Quality Study. The numbering of stations corresponds to that used for other phases of the March 1962 survey.

Certain physical and chemical conditions were determined at the time and place bottom animal samples were collected. The results of these determinations are shown in Table 2. With one exception, these physical and chemical conditions were within limits expected to support aquatic life. The exception was the high conductivity reading (40,000 μ mhos) in the Dolores River just above its confluence with the San Miguel (Station D-5) This value would indicate a salt content which would not likely be tolerated by aquatic animals. A bottom sample taken at this point produced no animals. The flow in the Dolores above the entrance of the San Miguel was very low (less than 1 cfs) and the salt contribution is probably at a minimum, but does increase conductivity values to a considerable extent at downstream stations. These values however are within limits expected to support aquatic life.

With the entrance of the Uravan mill effluents, the pH of the San Miguel is decreased about one unit and remains below normal stream levels for a considerable distance below. While the levels reached (7.2 - 7.8) are well within limits expected to support aquatic life, this decrease in pH could cause an increase in the toxicity of metals released in the mill effluents Dissolved oxygen, temperature and turbidity conditions were satisfactory for aquatic life support at all stations.

The results of bottom animal samples are shown in Table 3. The two stations (SM-6, SM-8), in the San Miguel above the Uravan mill outfall support large populations of a variety of clean water organisms. Below the mill, bottom animal populations are greatly diminished but apparently not completely eliminated as very limited populations were found at all downstream stations in both the San Miguel and Dolores. Very few mayflies or stoneflies are present but surprisingly, a fair number of caddisfly larvae are found. With the high toxicity of the effluents entering from the Uravan mill, it is surprising that bottom animals are not completely eliminated. Apparently, the large populations from above continually drift downstream and manage to survive for a while. Bottom animal populations found in August were slightly improved, especially in numbers of caddisfly larvae, over those found in March, especially at downstream stations. The San Miguel below the Uravan mill and the Dolores past the Utah border would be considered to be in very poor biological condition.

Table 1

Location of Sampling Stations
Dolores-San Miguel Rivers

Station	Mileage Index	Location
SM-6	C 1024-67-18	San Miguel 2 miles below VCA mill
SM-8	C 1024-67-5.5	San Miguel above Uravan
SM-9	C 1024-67-3	San Miguel below Uravan
SM-10	C 1024-67-0.1	San Miguel at mouth
D-15	C 1024-80	Dolores River at Bedrock
D-5	C 1024-67.1	Dolores above confluence of San Miguel
D-6	C 1024-63	Dolores 4 miles below confluence
D-9	C 1024-46	Dolores at mouth of Salt Canyon
D-11	C 1024-34	Dolores at Gateway
D-13	C 1024-24	Dolores at Hubbard Ranch

Table 2

Physical and Chemical Conditions
Dolores-San Miguel Rivers

Station	Date	Time	Temp. °F.	D.O. ppm	Cond. μ mhos	pH	Alk. ppm	Hardness ppm
SM-6	8-7-62	8:30A	16	8.2	480	8.2	94	220
SM-8	8-7-62	2:00P	23	7.2	625	8.4	102	280
SM-9	8-7-62	12:15P	21	7.4	810	7.2	92	340
SM-10	8-7-62	11:30A	20	8.0	825	7.3	76	350
D-15	8-7-62	9:30A	20	7.4	1,500	8.4	164	250
D-5	8-7-62	11:00A	21	7.0	40,000	8.2	174	1,820
D-6	8-7-62	2:45P	22	8.2	2,000	7.4	48	400
D-9	8-7-62	3:00P	25	7.6	2,600	7.8	34	520
D-11	8-7-62	4:30P	25	8.2	2,700	8.2	44	500
D-13	8-6-62	12:00M	22	7.6	2,300	8.1	56	475

Table 3

Bottom Animals
Dolores-San Miguel Rivers

Kind of Animal	Sta. SM-6	Sta. SM-8	Sta. SM-9	Sta. SM-10	Sta. D-6	Sta. D-9	Sta. D-11	Sta. D-13
	Number Organisms per Square Yard							
Hydracarina (Water Mites)		1			3	5		
Ephemeroptera (Mayflies)	250	527	1	1			4	26
Anisoptera (Dragonflies)	12	37	2	3	3	1		1
Plecoptera (Stoneflies)	12	60			1	1		
Hemiptera (Water Bugs)	1	2			2			
Megaloptera (Dobsonflies)								
Trichoptera (Caddisflies)	1,051	2,577	27	10	37	26	36	47
Coleoptera (Water Beetles)	5	30			9	46	10	7
Diptera (True Flies)	121	486	4		5	6	9	319
Oligochaeta (Earth Worms)		2			1	3	1	
Total Number	1,452	3,722	34	14	61	88	60	400
Weight (grams)	8.33	23.82	0.48	0.29	0.87	0.70	0.30	1.20

Boulderson - should do alpha or possibly others to have base line for ----
future developments using radioactive materials.

Activity: Radium Monitoring Network (Reference Summary Item 6, page 9)

Purpose: Routine continuous surveillance of the river waters of the entire Colorado River Basin for dissolved radium-226.

Such a network provides a continuous check on pollution of Basin waters due to the extensive uranium mining and milling in the Basin. The first network station was placed in operation in January 1961.

Summary of Progress:

Twenty-three Radium Monitoring Stations are currently operating. Six stations are located above any known source of radioactive pollution while the remainder are located below existing or potential sources of pollution. Seven stations are served by automatic sampling devices. The others are sampled on a grab-sample basis three to six times weekly.

Data obtained from these stations through December 31, 1962 have been reported in two data releases dated October 1962 and January 1963.

The data from the two releases are summarized as follows:

1. 323 samples have been analyzed and reported to date. The average of all data shows a radium-226 concentration of 0.36 μμc/l with a range of 0-3.3 μμc/l.

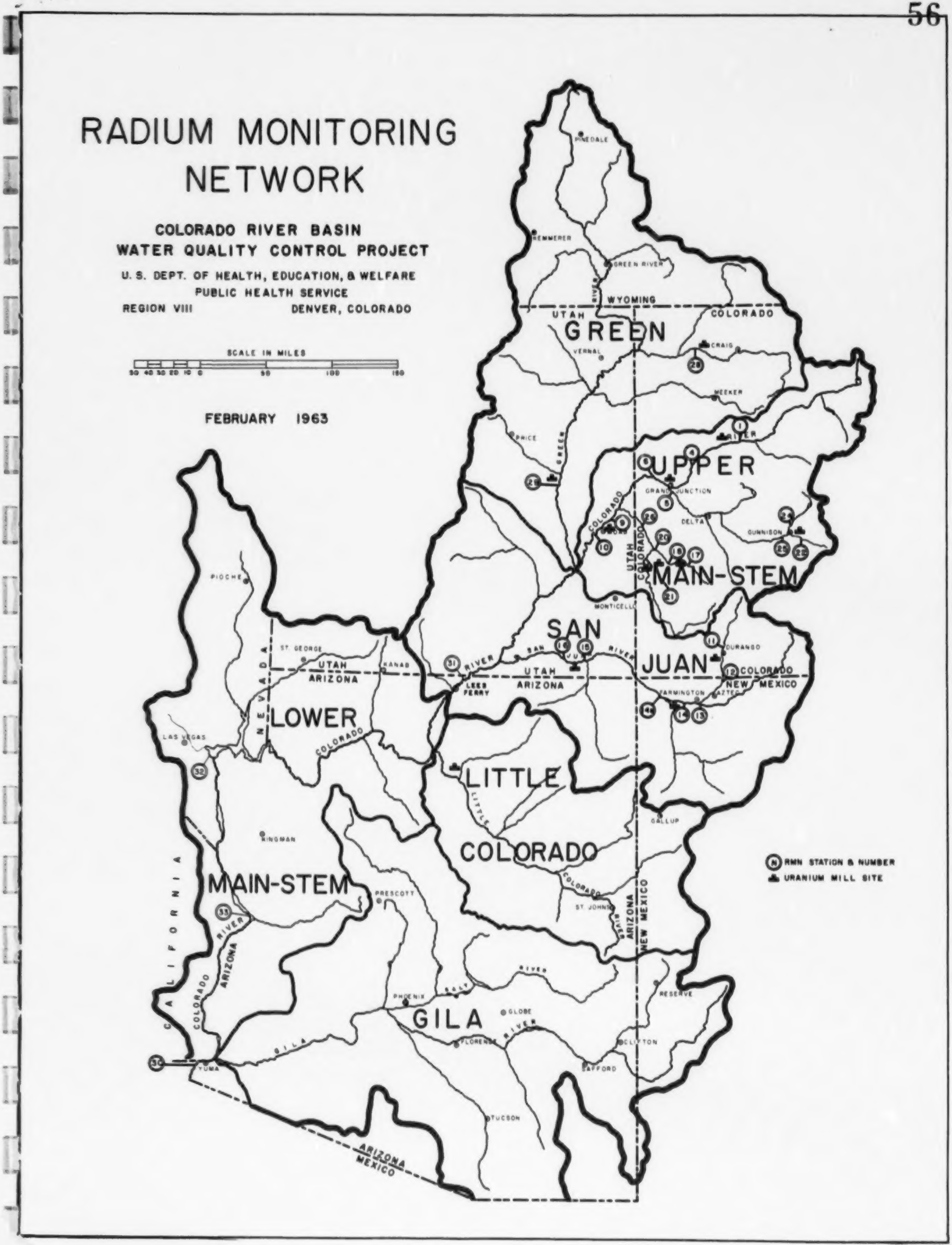
2. 67 samples representing natural background locations show an average radium concentration of 0.07 μμc/l with a range of 0-0.68 μμc/l.

3. The four non-background location stations in the San Miguel-Dolores river system show an average radium concentration of 0.80 μμc/l for 95 samples. The background location station (San Miguel River above Naturita) shows an average radium concentration of 0.04 μμc/l for 28 samples.

4. Of the total of 323 samples collected, 22 values have been greater than 1.0 μμc/l in radium-226. Of these 22, 21 have occurred in the San Miguel-Dolores River system.

Future Plans: Three additional sampling stations in the Lower Basin will be added in the near future to the existing Radium Monitoring Network. This will bring the total to 26 stations. Subsequent data releases are planned on a quarterly basis insofar as is practical.

Thatcher wants chemical data at Sta 9, 10, 15, 16



RADIUM MONITORING NETWORK

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
U. S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

FEBRUARY 1963

SCALE IN MILES
50 40 30 20 10 0 50 100 150
GREEN
UPPER
MAIN-STEM
SAN
JUAN
LITTLE
COLORADO
LOWER
MAIN-STEM
GILA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NEVADA
CALIFORNIA
ARIZONA MEXICO
PINEDALE
KEMMERER
GREEN RIVER
VERNAL
CRAIG
MEEKER
PRICE
GRAND JUNCTION
DELTA
GUNNISON
MONTICELLO
DURANGO
FARMINGTON
AZTEC
LEES FERRY
ST. GEORGE
KANAB
LAS VEGAS
PIOCHE
KINGMAN
PRESCOTT
GALLUP
ST. JOHNS
RESERVE
PHOENIX
GLOBE
FLORENCE
CLIFTON
SAFFORD
TUCSON
YUMA
RIVER
SALT
GILA
LITTLE
N RMN STATION & NUMBER
URANIUM MILL SITE

Activity: Basinwide Sediment Surveys

Purpose: The objectives of the Basinwide sediment surveys have been mainly (1) to determine the distribution of radioactivity in bottom sediments throughout the Basin; (2) to determine the natural background concentrations of radium-226 in Basin sediments; and (3) to assess the effects of uranium mill waste discharges upon the radioactivity of Basin sediments.

Summary of Progress:

Four Basinwide surveys have been conducted to date. These surveys occurred in August 1960, March 1961, August 1961, and September-December 1962. The results of the first three surveys have been presented in a detailed report which is in the final stages of preparation. The following general conclusions were reached from the data of the first three surveys.

1. Sediment collected from background locations averaged 1.1 μμc/gm radium-226 (45 samples).

2. All Colorado River Basin sediments averaged 2.4 μμc/gm radium-226 (254 samples).

3. Of the major Sub-Basins, the San Juan Sub-Basin sediments had an average radium content of 4.2 μμc/g (60 samples), the San Miguel-Dolores River system in the Upper Main Stem had an average radium content of 3.3 μμc/gm (66 samples), while the Lower Main-Stem Sub-Basin had a radium-226 average of 1.3 μμc/gm (38 samples).

4. Below Lake Mohave all sediments contained natural background concentrations of radium-226.

5. The data showed that Lakes Mead, Havasu and Mohave are the final resting places for radioactive sediment which moves downstream from the Upper Basin.

Future Plans:

The data from the fourth survey will be compared to the data from the first three surveys.

There are at present 88 locations throughout the Basin from which sediments are collected. The data gathered from the four surveys will be carefully examined and the number of sampling stations reduced to twenty to thirty.

A yearly collection (possibly in March before onset of high flows) from these 20-30 stations is anticipated.

Activity: Water Quality Management Program Development

Purpose: A determination of methods for securing the best possible water quality for multiple water use and the development of a program of water quality control for multiple water use within the Basin which can serve as a guide for the conference in progress and other enforcement actions which may be instituted subsequently, and to State and Federal agencies having an interest in the prevention and control of water quality degradation.

Summary Statement:

The development of the water quality management program for the Colorado River Basin will consist of several major steps. These are as follows:

1. An economic base study of the Basin.
2. Inventory of basic data on water quality, water uses, and waste discharges.
3. Study of Basin hydrology.
4. Projection of future water uses and waste discharges for alternative growth paths.
5. Development of a water quality management program to achieve optimum water use to gain maximum benefits, along with recommendations for implementing the program.

Details on the activities comprising the water quality management program, along with a statement of progress, will follow this summary on the overall program.

The water quality management program has been with the Colorado River Basin Water Quality Control Project since its inception. When the first session of the conference was held in Phoenix, Arizona on January 13, 1960, three of the State Conferees specifically requested that the Public Health Service undertake a study of potential pollution in the Basin. It was stressed that a preventative approach should be taken in the Colorado River Basin rather than taking corrective action after pollution exists.

As a result of this request the Public Health Service agreed to undertake the development of a water pollution control program for the Basin. The summary of the first session of the conference, dated June 30, 1960, stated the objective as mentioned above.

An outline of tentative plans for the water quality management program, dated June 8, 1960, was given to the conferees. This outline summarized the principal elements to be considered in developing the program. The work for each of the elements is already in progress or is planned for the near future.

One of the first steps of the study is to inventory the basin. This involves collection of all data on population, industry, resources, water uses, quality and quantity of existing water supplies, and sources of pollution.

Using the past trend data, and based on a study of the resources of the region, the location advantages, existing facilities and job opportunities, a projection of the general pattern of the economy of the area can be made. These projections would include population, industry, agriculture, recreation, fishing, and other major water-using and pollution contributing elements of society. The projections developed in the economic base study can then be translated into future water demands and pollution loads.

Quantity and quality of water are both necessary in the consideration of water supplies. Quantity requires a special study of river flow characteristics. The ground water situation is also studied. All available data on water quality are collected, and where gaps of knowledge exist, water samples are collected. Water quality data are then related to the existing water uses and to the geology of the area. In conjunction with the States, water quality objectives at certain critical points of the streams are determined.

After all of the elements of the program are available, they must be related.

On appropriate basin and sub-basin maps, the relative locations of present and probable future water needs, both quality and quantity, sources of water supply with quality and quantity, and sources of population are shown. With this background of information, and a knowledge of water quality objectives, the study can then be made to show how water supply can best be developed for the various needs and locations as indicated by alternative growth paths for economic development. The location of pollution sources and degree of treatment required would also be determined. The need for flow regulation for water quality control to provide water of suitable quality so as to permit re-use would be studied too.

Considering the alternative growth paths of the Basin economy, with the most effective combination of waste treatment requirements and flow regulation after treatment to protect and enhance water quality, a water quality management program will be developed consisting of several alternative plans to achieve the optimum use and re-use of the water so as to gain maximum public benefits from the water resources. Recommendations for implementing the program would also be included.

Activity: Economic Base Survey of the Colorado River Basin

Purpose: An economic base survey is a prime prerequisite to the preparation of a water quality management program for the Colorado River Basin. It is the key component in long range planning because it defines the growth path and time sequence of economic development for which alternative plans incorporated in the water quality management program will be developed.

The economic base survey provides an analysis of the economic characteristics, developments and long range trends of the past, as well as a projection of future economic development in the study area. Separate evaluations are required for each of the six sub-basins in order to correspond to the six separate water quality management programs for these sub-basins that will be prepared. The economic base survey identifies and measures, insofar as practicable, the economic, social, physical, geographical and technological factors relevant to economic development in the Basin. It must be flexible enough to allow for an evaluation of the effects of varying rates of growth for the various sectors of the Basin economy. Estimates of the expected time pattern of changes and development of economic conditions, both with and without water resource development and pollution control measures, are needed in order to constitute the framework within which the water quality management program will be formulated.

Summary of Progress:

The current staff of the Economic Studies group of the Colorado River Basin Water Quality Control Project consists of a senior economist (Chief, Economic Studies), a staff economist and a statistical clerk. The functions of this staff can be sub-divided into three broad categories:

1. Participation in the preparation of water quality management program reports for the Colorado River Basin and for each of the six sub-basins.

2. Supervision of economic studies carried out under contractual arrangement by the Associated Rocky Mountain Universities, Inc. and the Economic Research Service of the U. S. Department of Agriculture.

3. Preparation of economic sections in each of the flow regulation reports prepared by the Project.

Activity: Economic Base Survey of the Colorado River Basin (Continued)

Economic base survey activities were initiated in March 1961 when an economist was added to the Project staff. Initially, a plan of work for economic studies was prepared. The magnitude of the undertaking and the need for first-hand knowledge of economic development possibilities led to the conclusion that the overall base survey could best be handled by an outside agency through a contractual arrangement. Several research groups were contacted and as a result, the Associated Rocky Mountain Universities, Inc. was selected as the agency which would carry out the economic base survey. Pre-contract meetings with this agency were held in May and June of 1961. A reimbursement agreement was entered into with the Economic Research Service, U. S. Department of Agriculture for development of agricultural phases of the study. On November 15, 1961 a cost contract was entered into with the Associated Rocky Mountain Universities, Inc. in order to obtain their assistance in the development of methodology for the overall economic base survey. On the assumption that the economic base survey proper would not begin until July 1, 1962, arrangements were made for Project personnel to proceed with the collection of basic economic data from Bureau of Census and other available reports. Two statistical clerks and a second economist were added to the Project staff for this purpose. A number of basic data reports were prepared as well as a series of working papers on demographic characteristics.

Work on developing basic methodology for utilization of economic data in water quality management program reports was also carried out. The applicability of the inter-industry input-output approach was tested in a pilot study of the Animas-La Plata watersheds in southwestern Colorado and northeastern New Mexico.

Following a series of pre-contract meetings in early 1962, the economic base survey of the Green River sub-basin was initiated. A contract for ARMU assistance was signed in August 1962. Continued services of the Economic Research Service, U. S. Department of Agriculture, was also arranged for. The Green River Sub-Basin study began with a field interview period in November and December of 1962. This phase of the study is essentially completed.

Personnel from the Economic Studies group participated in a reconnaissance study of water quality and use aspects in the Price River Basin in east-central Utah. This study, carried out at the request of an in cooperation with the U. S. Army

Activity: Economic Base Survey (Continued)

Engineer District of Los Angeles, California, was initiated on July 1, 1962. Field work was completed during August and the first draft of a preliminary report was submitted to Washington Headquarters for clearance in September.

Future Plans:

Plans for future economic studies call for the continuation of the three broad areas of responsibility listed above. Specific work items are covered in other sections of this report dealing with work plans for developing the water quality management program and the preparation of flow regulation study reports.

Project plans call for the continued assistance of the Associated Rocky Mountain Universities, Inc. and the Economic Research Service, U. S. Department of Agriculture in the economic base survey activities. The proposed timetable for completion of their economic base survey reports follows:

1. Green River Sub-Basin - August 1963
2. Upper Main-Stem Sub-Basin - December 1963
3. San Juan Sub-Basin - August 1964
4. Little Colorado Sub-Basin - August 1964
5. Gila Sub-Basin - August 1965
6. Lower Main-Stem Sub-Basin - August 1965
7. Overall Summary Report - December 1965

Activity: Hydrologic Studies

Purpose: To define the present and future patterns of streamflow in the Basin.

Summary of Progress:

Discussions have been held with Mr. Frank Rainwater, Headquarters Hydrologist, and with the U. S. Geological Survey concerning Basin hydrological studies. The Bureau of Reclamation has been contacted regarding their plans for reservoir operations and the Project has received their operations studies.

Future Plans:

Plans for the overall approach that will be taken will be completed shortly and a detailed analysis of hydrologic data for key locations will be intitiated. It may be necessary to use computer services for this work. These studies will progress consistent with the overall Project needs for hydrologic data.

Activity: Analysis of historical U. S. Geological Survey water quality data.

Purpose: To find any changes in chemical quality in relation to location, season, period of record, or as a general function of discharge, and to give a basis for prediction of future quality.

Summary of Progress:

The first stage machine data analysis was completed and the results are being analyzed and interpreted. A partial summary of these results was given to the conferees in May 1962. The first stage analysis included the following programs:

1. Weighted concentrations of total dissolved solids, chlorides, and sulfates calculated on a monthly basis and plotted against time.

2. Calculation of the weighted flow rate, in average tons per day, for total dissolved solids, chlorides, and sulfates and plotted against time.

3. Calculation of the monthly average of the percent of each anion and cation to its respective total for the period of record.

4. The frequency of occurrence of samples equal to or greater than a given value.

5. Correllation of total dissolved solids data from each station with conductance and calculation of the least squares slope and ordinate intercept.

From an analysis of these programs, a second stage computer run was planned in order to expand the first stage results and to develop new correllations. This work is to be carried out shortly.

Future Plans:

The second stage machine data analysis to be carried out in the near future includes the following programs:

Activity: Analysis of historical U. S. Geological Survey water quality data (Continued).

1. A trend analysis by dry and wet seasons in order to determine if there is a significant change in quality through time.

2. Machine plotting of concentration vs. flows and the fitting of defined curves to these plots in order to establish a basis for predicting levels of concentrations at various flows.

3. Frequency analysis for all constituents to show the percent of time various levels of concentrations are exceeded.

4. Determining the predominant anion and cation at each station as an indicator of natural influences on water quality.

5. Find weighted concentrations and weighted flow rates for sodium, calcium, and magnesium for the purpose of analyzing the data so that it may be related to parameters affecting water quality.

Activity: Development of Inventory on Municipal and Industrial Water Use and Waste Discharges in the Basin.

Purpose: To locate points of water use and waste discharge, determine quantities involved, waste characteristics, and analyze effects of discharges on water uses.

Summary of Progress:

Collection of basic data has taken place at intervals during the past 2 years. Municipal data is relatively complete for the present situation. Industrial data still has some gaps. Basic data is being tabulated and summarized for the Green Sub-Basin.

Future Plans:

Where feasible, industrial data gaps will be filled by sending out questionnaires or personal contacts. It is also planned to obtain trend data for municipal water use where possible.

must not introduce these at formal conference

Activity: Establishment of Water Quality Objectives for the Colorado River Basin.

Purpose: To have a basis for comparing existing and future water quality in the Colorado River Basin to levels that are desirable or necessary for the utilization of the waters for all legitimate water uses.

Summary of Progress and Future Plans:

A draft of a set of water quality objectives has been completed and is attached. This draft is presented for discussion purposes among the water pollution control agencies of the seven Basin states. It is hoped that after any suitable modifications that may be necessary, the states will agree on the water quality objectives that should be used by the Colorado River Basin Water Quality Control Project in its development of a water quality management plan for the Basin.

Pollution
1. degradation of water quality
2. interference with beneficial use

Wants more review of state laws and policies

Guidelines for objectives must come out very soon. Guidelines not specific figures.

This is a group std for planning purposes.

WATER QUALITY OBJECTIVES OF THE COLORADO RIVER BASIN

A. Policies

1. Because of the need for full utilization of the water resources in the Colorado River Basin for all beneficial uses, it is the policy of the water pollution control agencies of the seven Basin states that the discharge of pollutional constituents into waters of the Colorado River Basin be so regulated as to achieve the highest possible water quality consistent with maximum benefit to the people, in contrast to following a direction of making maximum use of receiving waters for waste assimilation.

2. Preventive control and abatement of pollution of surface and ground waters for present and future beneficial uses will be exercised with the objective of sustaining the beneficial uses of the natural resources of the Colorado River Basin.

3. Requirements for all waste discharges shall preclude unreasonable harm by such discharges to other water users or resources which are dependent upon the quality of the receiving waters.

4. Consideration shall be given to the provision of storage for regulation of streamflow for the purpose of water quality control. However, such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling waste at the source.

B. Objectives

The quality of waters in the Colorado River Basin shall be such that beneficial uses of these waters will not be adversely affected. As a guide in evaluating the suitability of these waters, the objectives for various uses are listed.

1. Municipal and Domestic

In establishing water quality objectives for domestic use, the quality of the water at the source of supply and its quality at the house tap must be considered. The quality of water of the source is of interest insofar as it may affect the quality of water delivered to the customer or as it may affect the water treatment processes.

Considerations regarding the quality of source water for municipal and domestic purposes are as follows:

Bacteriological characteristics. In order to achieve a satisfactorily low bacteriological concentration in the treated water, the average monthly coliform concentration of the source water should not exceed 5000 per 100 milliliters.

Physical characteristics. The physical characteristics should be such as to permit the achievement of satisfactory physical water quality with normal treatment.

Chemical characteristics. The limits for chemical elements or compounds in water are divided into those which constitute grounds for rejection of the supply and those which preferably should not occur in excess of the specified concentrations.

The presence of the following substances in excess of the concentrations listed constitute grounds for rejection of the supply:

Substance	Concentration in ppm
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	1.4 to 2.4 (depending on temperature)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

The following chemical substances should not be present in a water supply in excess of the listed concentrations where other more suitable supplies are or can be made available.

Substance	Concentration in ppm
Alkyl benzene sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.0
Carbon chloroform extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	0.08 to 1.7 (depending on temp.)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total dissolved solids	500.
Zinc (Zn)	5.0

Radioactivity. The effects of human radiation exposure are considered harmful, and it is recommended that all unnecessary exposure to ionizing radiation be avoided. Approval of water supplies containing radioactive materials shall be based upon the judgment that the radioactivity intake from such water supplies when added to that from all other sources is not likely to result in an intake greater than the radiation protection guidance recommended by the Federal Radiation Council and approved by the President. In order to keep the exposure of the public to radioactivity to a minimum, municipal water supplies in the Colorado River Basin should contain a maximum of 1.0 micro-micro-curie of radium-226 per liter of water and a maximum of 10 micro-micro-curies of strontium-90 per liter of water.

Miscellaneous. The 5-day biochemical oxygen demand of water used as a source of domestic supply should not exceed 5 ppm. The pH should not be lower than 5.0 or greater than 9.0.

The public water system of the modern municipality serves as a source of supply for many users in addition to domestic use, and the requirements of many users of municipal water are more critical than those of domestic users. Municipal water, therefore, should be of the highest possible quality.

2. Industrial

No single characterization of the water quality needs of industry is possible, since the requirements are as varied as industry itself. One characteristic, however, is of primary importance to all industries: the concentrations of the various constituents of the water must remain relatively constant. It is an accepted practice for industry to evaluate water quality at the time a plant is constructed and to provide for any deficiencies of quality in the design of treatment facilities. Although the economics of required treatment naturally affect decisions on plant locations, initial quality normally is not so great a concern to the industrialist as the possibility that water quality characteristics will change and possibly vary widely after the plant is in operation.

It is recognized that water quality at the water intake can be improved by treatment to reduce certain deleterious constituents that may not be desired in industrial process water. The water quality requirements of the process water, however, can serve as a guide in evaluating the quality at the water intake.

Although hardness is a characteristic often used to classify water as to suitability for industrial use, other constituents may be more relevant to the suitability of water for particular uses. These constituents may be significant in terms of the various objectionable effects related to industrial uses of water.

Silica is objectionable in boilers, especially high-pressure boilers, because it tends to form adherent deposits on heat-transfer surfaces. Silica deposits also form on hydraulic turbine blades and cause severe damage if they are not removed.

Iron and manganese in relatively small concentrations cause stains and deposits. Iron sometimes is accompanied by iron bacteria. The latter frequently cause deposits and odors in water systems.

Sodium and potassium do not cause hardness and normally are not associated with scale deposits. These cations, especially sodium, are concentrated in boiler water and have to be removed by continuous or intermittent blowdown.

Sulfate in water tends to form hard, adherent scale on heat-transfer surfaces. Sulfate usually is associated with noncarbonate hardness and is difficult to remove economically.

Chloride in concentrations less than 50 ppm normally is not detrimental to most industrial uses, and higher concentrations frequently are used. Chloride in boiler water contributes to the total concentration of dissolved solids. Thus, if the boiler feed water contains substantial amounts of chloride, periods of blowdown will be more frequent. High chloride waters also promote corrosion of metal surfaces.

Hydrogen-ion concentration, or pH (a measure of hydrogen-ion activity), is related to the acidity or basicity of a water. Hydrogen-ion concentration often is used for classifying water for industrial purposes, especially where water is carried in long pipelines, stored, or used in corrodible equipment.

Although many studies have been made of the quality requirements for use in certain industries, many requirements have been specified only generally in public documents. The attached table contains data on the water quality requirements for certain industrial uses which have been published. In reviewing this table, it must be recognized that the characteristics specified may not be applicable to any particular industrial plant, because of individual variations in product manufacture. This is particularly true of such industrial groups as the chemical process industries, in which processes and practices vary widely and often change as research develops improved techniques or new products.

3. Irrigation.

In a discussion of the quality of water for irrigation, it is necessary to consider the effect of quality characteristics on both the plant and the soil. A water excellent for some purposes may be inferior for irrigation use. In fact, water quality criteria, from the standpoint of soil and plant relationships, differ generally from the criteria for domestic or industrial water. For example, irrigation water should contain a relatively high proportion of calcium and magnesium, but soft water is preferred for domestic use. The concentration of boron in irrigation water could be critical although the same concentrations are not important in domestic waters. Although silica and fluoride are undesirable constituents in household water, they present no particular hazard in irrigation water. One quality preferred in all waters is a low total salt content.

The deleterious effects of salts on plant growth can result from direct physical effects of salts in preventing water uptake by plants (osmotic effects); direct chemical effects upon the metabolic reaction of plants; and indirect effects through changes in soil structure, permeability, and aeration.

(All entries are

	Turbidity	Color	Oxygen Consumed	Dissolved Oxygen	Taste and Odor	PH	Hardness	Alkalinity	Calcium	Chlorides	Calcium Chloride	Magnesium Chloride
Air conditioning												
Baking	10	10			None		1/		1/			
Boiler feedwater												
0-150 psi	20	80	15	1.4		8.0+	80					
150-250 psi	10	40	10	0.1		8.4+	40					
250-400 psi	5	5	4	0		9.0+	10					
over 400 psi	1	2	3	0		9.6+	2					
Brewing												
Light beer	10	10			None	6.5-7.0		75-80	100-200		100-200	100-200
Dark beer	10	10			None	6.5-7.0	250	80-150	200-500		100-200	100-200
Carbonated beverages	2	10	1.5		None			50-170		250		
Chemical process industries	(Requirements vary widely within industry and process used; sometimes distilled water must be used.)											
Concrete mixing4/												
Confectionary					Low	7.0+						
Cooling water	50					6.5-7.5	50					
Electroplating							Low					
Fermentation	Same general requirements as brewing. (Requirements for gin and spirits equal light beer and requi											
Food canning and freezing	10				None	7.5+	6/	30-250				
Food equipment washing	1	20			None		10			250		
Food processing - general	10	10			Low		250	250				
Ice manufacture	5	5	3		None		70	30-50			300	170-300
Laundering						6.0-6.8	50	60				
Oilwell flooding	0					7.0+		Low				
Photographic processing	2	2					100					
Plastics - clear - uncolored	2	2										
Paper and pulp												
Groundwood pulp	50	30					200	150		25		
Soda and sulfate pulp	25	5					100	75		75		
Kraft												
Bleached	40	25					100	75		200		
Unbleached	100	100					200	150		200		
Fine paper	10	5					100	40-75				
Rayon (Viscose)												
Pulp production	5	5					8	50				
Manufacture	0.3					7.8-8.3	55	50-75				
Steel manufacturing						6.8-7.0	50			175		
Sugar manufacturing									20	20		5/
Tanning	20	10-100				6.8-8.0	50-513	128-135				
Textile manufacturing												
General	0.3-25	5-70	8				0-50		10	100		9/
Dyeing	5	5-20					20					
Wool scouring		70					20					
Cotton	5	5			Low		20					

1/ Calcium is necessary for some yeast actions, so some hardness is desirable. Too much hardness, however, retards fermentation
2/ Except as specified, should conform to Public Health Service drinking water standards.
3/ Although the total dissolved solids limit is 500-1,000 p.p.m., there is a limit of 300 p.p.m. for any one substance.
4/ Water should be free of acids, alkalies, oil, and decayed vegetable matter. Sugar should not exceed 3,400 p.p.m.; SO_3 should
5/ Magnesium in any form should not exceed 10 p.p.m.
6/ No chlorophenols. Hardness varies with product: general canning and freezing 50-85 p.p.m.; peas 200-400 p.p.m.; fruits and ve
7/ Turbidity as SiO_2 must not be gritty.
8/ Calcium hardness as $CaCO_3$ should not exceed 50 p.p.m. Magnesium hardness as $CaCO_3$ should not exceed 50 p.p.m.
9/ Magnesium should not exceed 5 p.p.m.

TABLE II-9-1

WATER QUALITY TOLERANCES FOR INDUSTRIAL APPLICATIONS

(All entries are maximum values unless indicated by plus sign; where range is indicated, both extremes are entered.)

Calcium	Chlorides	Calcium Chloride	Magnesium Chloride	Sodium Chloride	Sulfates	Magnesium Sulfates	Calcium Sulfates	Sodium Sulfate	Total Dissolved Solids	Total Solids	Iron	Manganese	Iron and Manganese Together	Aluminum Oxide	Silica	Copper	Fluoride
											0.5	0.5	0.5				
											0.2	0.2	0.2				
1/																	
										500-3000				5.0	40		
										500-2500				0.5	20		
										100-1500				0.05	5		
										50				0.01	1		
100-200		100-200	100-200	275-500		100-200	100-500	100	500-1000		0.1	0.1	0.1		50		1.0
200-500		100-200	100-200	275-500		100-200	100-500	100			0.1	0.1	0.1		50		1.0
	250				250				850		0.1	0.2	0.2				0.2-1.0
etimes distilled water must be used.)																	
					Low	Low		Low									
									100		0.2	0.2	0.2				
											0.5	0.5	0.5				
					Low						Low						
spirits equal light beer and requirements for whiskey equal dark beer.)																	
				1500							0.2	0.2	0.2				1.0
	250								850				0.2				1.0
									850		0.2	0.2	0.3				1.0
		300	170-300	300		130-300	300	300	170-1300		0.2	0.2	0.2		10		1.0
											0.2	0.2	0.2				
											0.1						
							>100		Low	200	0.02	0.02	0.02				
										200	0.02	0.02	0.02				
	25								500		0.3	0.1			50		
	75								250		0.1	0.05			20		
	200								300		0.2	0.1			50		
	200								500		1.0	0.5			100		
									200		0.1	0.05			20		
										100	0.05	0.03	0.05	8.0	<25	<5	
											0.0	0.0	0.0				
	175																
20	20		5/		20	5/					0.1						
											0.1	0.1	0.2				
10	100		9/		100	9/					0.1-1.0	0.05-1.0	0.2-1.0				
											0.25	0.25	0.25				
											1.0	1.0	1.0				
											0.2	0.2	0.2				

dness, however, retards fermentation and causes soggy bread.

p.m. for any one substance.
not exceed 3,400 p.p.m.; SO_3 should not exceed 25 p.p.m.

.; peas 200-400 p.p.m.; fruits and vegetables 100-200 p.p.m.; legumes 25-75 p.p.m.

not exceed 50 p.p.m.

TABLE II-9-1

ATIONS

s indicated, both extremes are entered.)

Total Solids	Iron	Manganese	Iron and Manganese Together	Aluminum Oxide	Silica	Copper	Fluoride	Carbonate	Sodium Carbonate	Bicarbonate	Nitrate	Hydroxide	Hydrogen Sulfide	Algae Protozoa	Corrosion Tendencies	Scale-forming Tendencies	Slime-forming Tendencies	Free Carbon Dioxide	General Notes
	0.5	0.5	0.5										None	None	No		No		
	0.2	0.2	0.2										0.2						1/ 2/
00-3000				5.0	40			200		50		50	5.0		No	No			
00-2500				0.5	20			100		30		40	3.0		No	No			
00-1500				0.05	5			40		5		30	0		No	No			
50				0.01	1			20		0		15	0		No	No			
	0.1	0.1	0.1		50		1.0	50-68	100		30		0.2						3/
	0.1	0.1	0.1		50		1.0	50-68	100		30		0.2						
	0.1	0.2	0.2				0.2-1.0						0.2	None					2/
	0.2	0.2	0.2												No			20	2/ 4/
	0.5	0.5	0.5										0.2	Low	No	No	No		2/
	Low							Low			Low							15	
	0.2	0.2	0.2				1.0						1.0						2/ 6/
			0.2				1.0												2/
	0.2	0.2	0.3				1.0												2/
	0.2	0.2	0.2		10		1.0			50									2/
	0.2	0.2	0.2							Low									
	0.1													None					
0	0.02	0.02	0.02																
0	0.02	0.02	0.02																
	0.3	0.1			50													10	7/
	0.1	0.05			20													10	7/ 8/
	0.2	0.1			50													10	
	1.0	0.5			100													10	
	0.1	0.05			20													10	
0	0.05	0.03	0.05	8.0	<25	<5													
	0.0	0.0	0.0																
	0.1									100					No				5/
	0.1	0.1	0.2							Low								Low	
	0.1-1.0	0.05-1.0	0.2-1.0							200									
	0.25	0.25	0.25								Low								
	1.0	1.0	1.0																
	0.2	0.2	0.2																

No rigid limits of salinity can be set for irrigation waters for several reasons:

(a) The soil solution may be 3 to 8 times as concentrated as the water applied to it because of the evaporation of water from the soil surface, transpiration of plants, and the selective absorption of salts by the plants;

(b) Plants vary widely in their tolerance of salinity as well as specific salt constituents;

(c) The effect of one ion may be modified by the presence of another; and

(d) Climatic conditions, soil type, and irrigation practices all may influence the reaction of the crop to the salt constituents. Good drainage of the soil may be a more important factor for crop growth than the salts in the irrigation supply. Even when excellent waters are used, poorly drained land may be unproductive, while on the other hand open, well-drained soils may be productive with saline waters.

As a guide for estimating the suitability of water for irrigation the following qualitative classification or irrigation waters is presented:

Chemical properties	Class 1	Class 2	Class 3
	Excellent to good	Good to injurious	Injurious to Unsatisfactory
	(Suitable for most plants under any conditions of soil & climate)	(Possibly harmful for some crops under certain soil conditions)	(Harmful to most crops and unsatisfactory for all but the most tolerant
Total dissolved solids			
In ppm	Less than 700	700 - 2,000	More than 2,000
Chloride ion concentration			
In ppm	Less than 175	175 - 350	More than 350

The relationship of sodium to calcium and magnesium is the important factor in determining irrigation water quality. Sodium can be expressed in parts per million, milliequivalents per liter, or as a percentage. None of these methods of expression, however, is completely satisfactory to the agronomist. An expression called the sodium adsorption ratio (SAR) is preferred.

$$SAR = \frac{Na^{+}}{\left(\frac{Ca^{++} + Mg^{++}}{2}\right)^{1/2}}$$

The SAR of an irrigation water is related to the exchangeable-sodium percentage of the soil irrigated with that water. Exchangeable sodium is that fraction of the soil sodium which is adsorbed by the soil and may be replaced by or exchanged with other salt constituents, such as calcium or magnesium. Soils containing excessive exchangeable sodium are called sodic soils. These soils usually take water slowly, crust when dry, become sticky when wet, and have a black surface. Irrigation waters with SAR values of 8 or less are classified as safe. Values of 12 or 15 are marginal, and the continued use of waters with values much greater than 20 undoubtedly would lead to serious sodium problems.

Boron is essential to normal plant growth, but concentrations only slightly above optimum are toxic to many plants. This element has little or no effect on soils. Permissible limits of boron in irrigation water are 0.3-1.0 ppm for sensitive crops, 1.0-2.0 ppm for semitolerant crops, and 2.0-4.0 ppm for tolerant crops. The sensitive group includes such crops as citrus and other fruits, nuts, and beans; the semi-tolerant group includes alfalfa, sugar beets, and asparagus.

4. Stock and Wildlife Watering.

Despite considerable research in the field of animal husbandry, there is a surprising lack of definite information concerning the quality of water necessary for livestock and poultry use, with the possible exception of tolerances for chlorides, and here many conflicts exist in the literature.

It appears reasonable to assume that many bacterial diseases may be transmitted to livestock as well as to man by infected water. Cattle and swine, however, have had access to polluted water containing sewage and sewage effluents for fairly long periods without bacterial infection. More research is needed on this subject before specific water quality requirements can be established.

Algae, which are not a pollutant but may result from pollution, particularly by nutrients, have been the suspected cause of the illness and death of a great variety of animals. Certain algae may be toxic to all warmblooded animals, and efforts are being made to identify and isolate the particular species involved.

When water used for livestock watering is heavily saturated with chlorides, sulfates, carbonates, bicarbonates, sodium, calcium and magnesium, the injury caused represents an osmotic effect of the total salts present rather than a toxic effect of any constituent. The maximum concentrations of salt which can be tolerated safely by domestic animals are reported to be between 15,000 and 17,000 ppm, although it is recognized that this limit may be too high for animals in production. Lactation and reproduction generally are the first functions to be disturbed by the continuous use of waters with unfavorable mineral concentrations. Within limits, however, animals can adjust to the use of saline waters, provided the change is not too sudden. The tolerance of animals to salt in water also depends upon species, age, and physiological condition, as well as other factors, such as the salt content of the diet and the season of the year.

Oil slicks in water have adverse effects on waterfowl. A few drops of oil coming in contact with the plumage may destroy its waterproof nature and subject the bird to exposure, or, if the oil is ingested, may have toxic effects.

5. Recreational Uses.

Waters used for swimming, bathing, boating, and esthetic enjoyment should conform to three conditions:

(i) These waters should not exceed 1000 coliform organisms of sewage origin per 100 ml;

(ii) They should contain no substance which is toxic upon ingestion or irritating to the skin; and

(iii) They should be esthetically pleasant; that is, free from obnixious floating or suspended substances, objectionable color, and foul odor.

6. Propagation of Fish and Other Aquatic Life.

Probably the greatest single recreational use of water is for sport fishing, and consequently there is considerable published material on the effect of water quality on fishlife. Unfortunately, there has been no standardized research approach, and the conditions under which numerous investigators have conducted their experiments have varied widely. Investigators therefore do not always agree on the effects of specific pollutants. Certain generalized conclusions may be reached, however.

Some of the variables which affect the response of fish to water quality are as follows:

(i) Species, size, age, and physiological condition (Water which is of satisfactory quality for some species may be unsatisfactory for others that have been adapted to different environmental conditions.);

(ii) Hydrographical features of water sources and fluctuating water levels, particularly in impoundments; and

(iii) Physical and chemical composition of the environment. (For example, the damaging effect of poisons generally are greater in soft water than in hard water. It is known also that the combined influence of several substances simultaneously may result in greater damage to fish population than the sum of the individual effects taken independtly, and, conversely, certain combinations of salts may offset the injurious effects of each other.)

Despite all the variables, the following are generally accepted as limiting concentrations:

> Dissolved oxygen not less than 5 ppm; pH 6.3 to 9.0; free carbon dioxide not over 3 cc./liter; and ammonia not over 1.5 ppm.

Limits are not established for the multitude of individual elements and compounds which may be toxic to fish since the response varies with the species and environmental conditions. Especially detrimental are the insecticides and other economic poisons which are being used widely. Recent research indicates that fish are extremely sensitive to certain insecticides, and agricultural drainage following precipitation has caused sizeable fish kills. Waters of the Colorado River Basin should not contain any of these substances in concentrations that are toxic to fish.

7. Power Production and Cooling Waters.

Generally speaking, the quality requirements for water used for power are not high. However, water used for this purpose:

(a) Should not contain organic matter that generates putrescible odors and corrosive hydrogen sulfide gas;

(b) Should not contain debris, silt, and other suspended solids that block channels and intake devices or settle in reservoirs to reduce useful storage;

(c) Should not contain materials which are corrosive; and

(d) Should not contain algae, fungi, or other materials that clog passageways.

Activity: Water Quality Management Program for Upper Main-Stem (Reference Summary Item 1, page 8)

Purpose: The water quality management program for the Colorado River Basin was specifically requested by the Conferees at the January 13, 1960 meeting at Phoenix, Arizona. Six separate portions of the program will be carried out, one for each of the six major Sub-Basins. The purpose is to determine methods for securing the best possible water quality for multiple water use. The programs developed can serve as guides for the conference in progress and other enforcement actions which may be instituted subsequently, and to State and Federal agencies having an interest in the prevention and control of water quality degredation. A more detailed statement on the water quality management program in the Colorado River Basin will be found in another section.

Summary of Progress:

A number of studies which relate specifically to the Upper Main-Stem water quality management program were carried out. These are as follows:

1. Water quality network to study overall salinity.

2. Field survey to study salinity in the Gunnison River Basin.

3. Field survey to study dissolved oxygen and stratification in lakes.

4. Collection of demographic and economic data for the economic base study of sub-basin.

Many other facets of project work relate to the Upper Main-Stem but also relate to other sub-basins. Examples are the computer analyses of water quality data, preparation of inventories of basic data, hydrologic studies, water quality objections, etc. Field work is essentially completed for this sub-basin.

Future Plans:

The economic base study for the Upper Main-Stem Sub-Basin will be completed about December 1963. The projections contained therein will be related to future water uses and waste discharges. Means for prevention of future degradation of water quality and methods for securing the best possible water quality for multiple water use will be studied.

Activity: Animas-La Plata Water Quality Study

Purpose: This is a pilot study to develop a water quality management plan for the study area.

Summary of Progress:

A field survey was carried out during the summer of 1961. A summary of water quality data from this survey was given to the Conferees in May 1962. The economic base study for the area has been completed and will be distributed to the Conferees shortly.

Future Plans: It is expected that the final report will be completed about June 1963 and distributed to the Conferces. This report will contain an example of a water quality management plan.

Don't throw out at a formal conference.

Activity: Gunnison River Basin Water Quality Study

Purpose: This survey was primarily conducted to evaluate the effects of extensive irrigation on the water quality of Gunnison River system and the associated problem of salinity buildup in the river system. Data obtained will be used in the preparation of the Upper Main-Stem water quality management plan.

Summary of Progress: The Gunnison River Basin water quality study was carried out August 27-September 8, 1962 with the Montrose, Colorado Sewage Treatment Plant as survey headquarters and location of temporary laboratory facilities.

The data from this survey has been received from the Project Laboratory and is now in stage of preliminary analysis. The effect of irrigation return flows to the streams can be seen on the plot of total dissolved solids.

Irrigation areas in the Gunnison River Basin are located primarily along the Uncompahgre and North Fork Rivers with some along the Gunnison itself in the vicinity of its confluence with these two major tributaries. Most of the dissolved solids contribution to the Gunnison River is from the Uncompahgre and North Fork Rivers. Some contribution independent of these streams enters the Gunnison in the stretch from below the North Fork to just downstream of the Uncompahgre.

On the Uncompahgre River the majority of irrigation is below Colona, Colorado at river mile 43, to the mouth. It is also below Colona that the major contribution of dissolved solids is added to the stream. The North Fork has irrigated acreages downstream from Somerset, Colorado, and is also the area of the highest solids increase.

From analysis of this date, it would appear that returns to the river in irrigated areas are responsible for most of the salinity increase in the river system.

Future Plans: Data analysis will continue for the remainder of Fiscal Year 1963 with some time evaluating irrigation effects on the stream system. Biological analysis will also be undertaken. A report on the survey and the river basin will be written and published in Fiscal Year 1964.

Gunnison River Basin Water Quality Study
August 27-September 8, 1962

Total Dissolved Solids

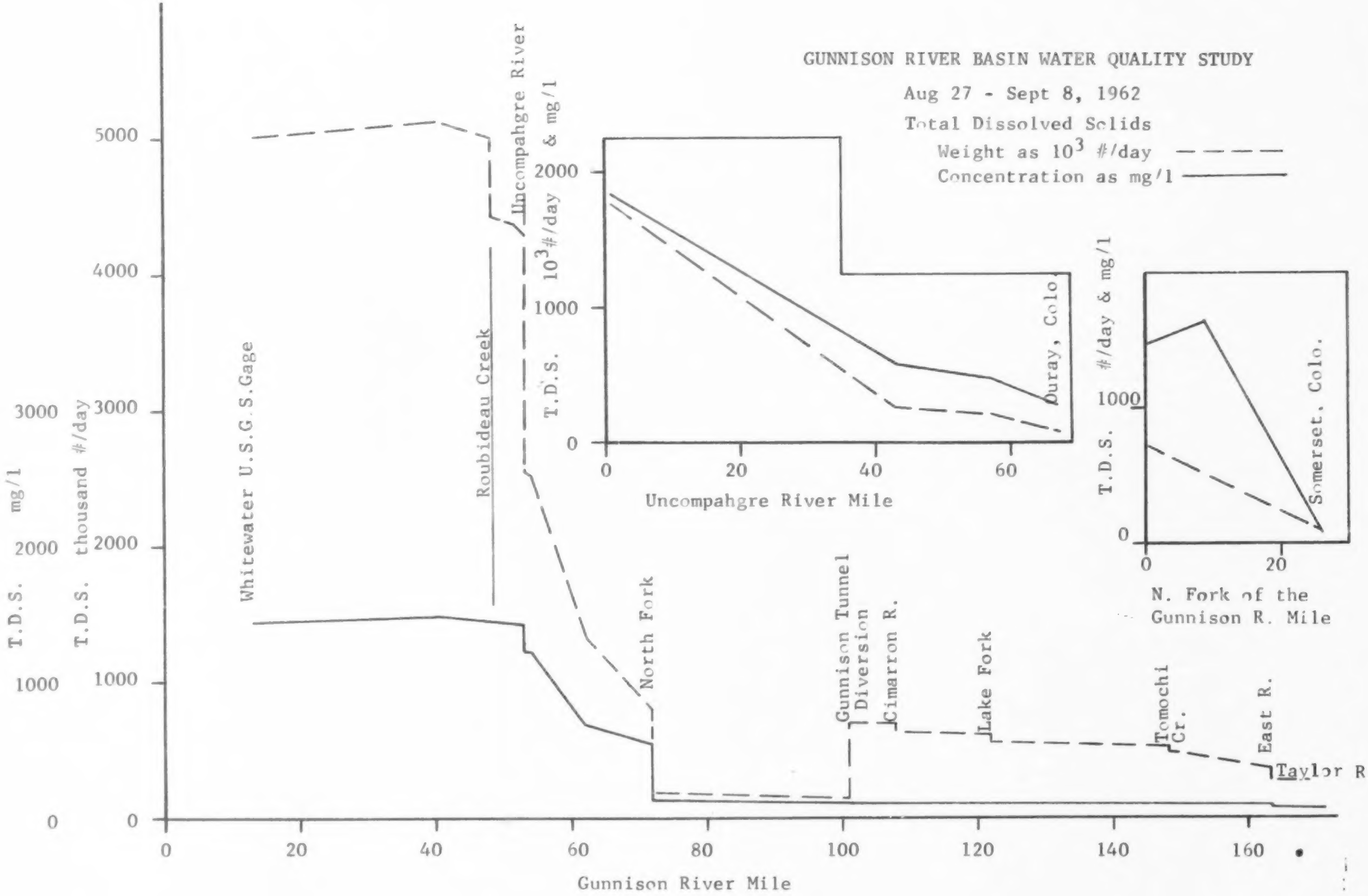
Station Number	Description of Station	River Mile	T. D. S. mg/1	T. D. S. 10^3 #/day
GR-1	Taylor River at mouth (at USGS gage)	163.5	53	256
GR-2	East River at mouth (at USGS gage)	163.5	173	107
GR-3	Gunnison River off Hwy 50 Bridge at Gunnison, Colorado	150.5	94	479
GR-4	Tomichi Creek at mouth	148.4	167	43.2
GR-5	Lake Fork Gunnison River at mouth	122.0	91	490
GR-6	Cimmaron River near mouth (at USGS gage)	108.8	654	52.5
GR-7	Gunnison River at Montrose end of Gunnison Tunnel	100.8	106	548
GR-8	Gunnison River immediately above North Fork Gunnison River	72.1	141	189
GR-9	North Fork, Gunnison River near Somerset, Colorado	26.4	84	95
GR-10	North Fork, Gunnison River at Hotchkiss, Colorado	8.8	1645	1144
GR-11	North Fork Gunnison River near mouth	72.0	1492	717
GR-12	Gunnison River at Austin, Colorado	62.4	681	1332
GR-14	Gunnison River at Route 50 bridge crossing	54.3	1211	2509
GR-15	Uncompahgre River at Ouray	67.2	291	74
GR-16	Uncompahgre River near Ridgeway, Colorado	56.8	488	203
GR-17	Uncompahgre River near Colona, Colorado	42.8	595	260
GR-18	Uncompahgre River at Delta, Colorado	1.2-53	1835	1770
GR-19	Gunnison River from main highway bridge below Delta, Colorado	51.0	1410	4381
GR-20	Rubideau Creek near mouth	48.0	1735	572
GR-21	Gunnison River from bridge off Escalante Canyon Road	40.2	1477	5131
GR-22	Gunnison River at Whitewater	13.2	1447	5012

Gunnison River Basin Water Quality Study
August 27-September 8, 1962

Individual Constituent Concentrations

Concentration mg/l

Station Number	Ca^{++}	Mg^{++}	Na^{+}	HCO_3	$SO_4^{=}$	Cl^{-}
GR-1	12.4	3.1	1.6	53	7.6	1.0
GR-2	48.9	8.1	3.3	164.4	28.4	1.0
GR-3	24.0	5.4	2.2	98.0	11.5	1.0
GR-4	41.4	10.0	5.8	175.	18.2	1.4
GR-5	22	30	3.9	59	30	1.0
GR-6	90	48	53.0	247	328	6.2
GR-7	25	5.8	4.1	94	22	1.0
GR-8	30	8.3	7.9	103	42	2.8
GR-9	21	3.7	5.1	89	8.3	1.0
GR-10	222	114	118	298	1024	12.0
GR-11	185	107	120	275	923	14.0
GR-12	92	41	67	177	379	15.0
GR-14	161	64	123	228	725	18.0
GR-15	71	3.3	14.6	6.7	197	1.4
GR-16	114	17	12	167	256	3.9
GR-17	127	25	19.5	200	316	4.6
GR-18	276	83	172	297	1139	11.2
GR-19	199	69	135	252	849	22
GR-20	293	95	96	253	1115	10.8
GR-21	215	70	135	239	916	16.4
GR-22	200	70	135	213	896	18.4



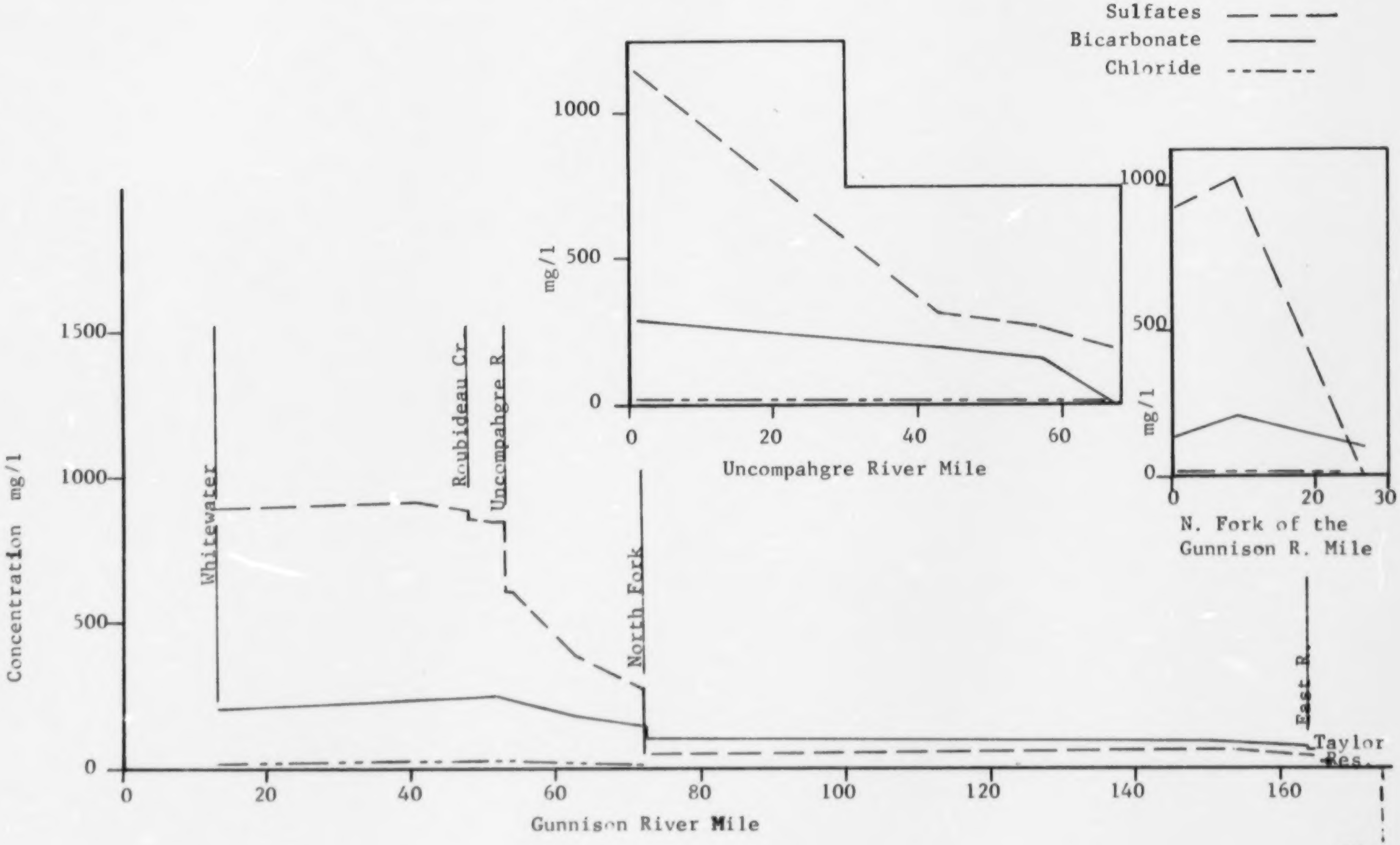
GUNNISON RIVER BASIN WATER QUALITY STUDY

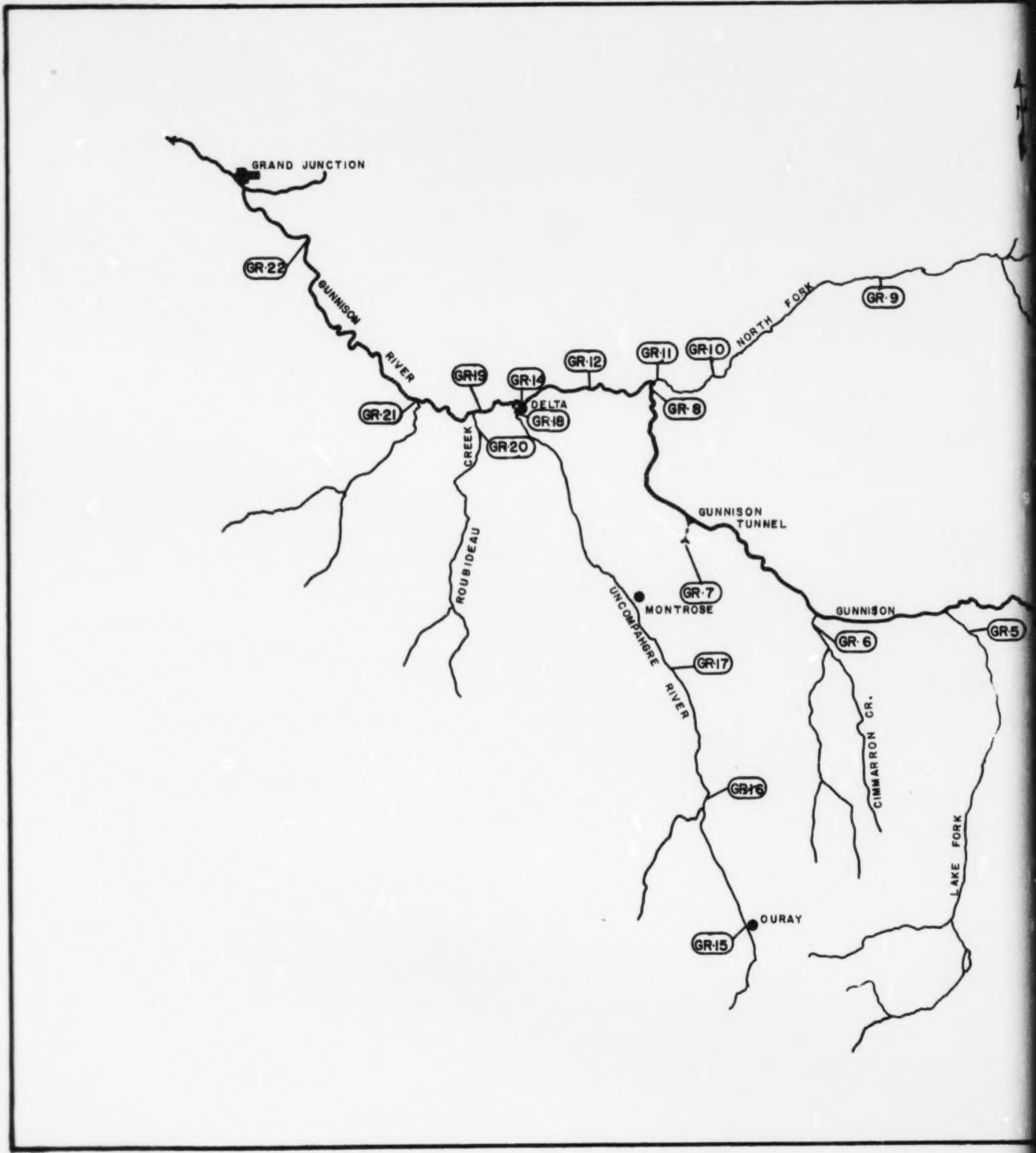
Aug 27 - Sept 8, 1962

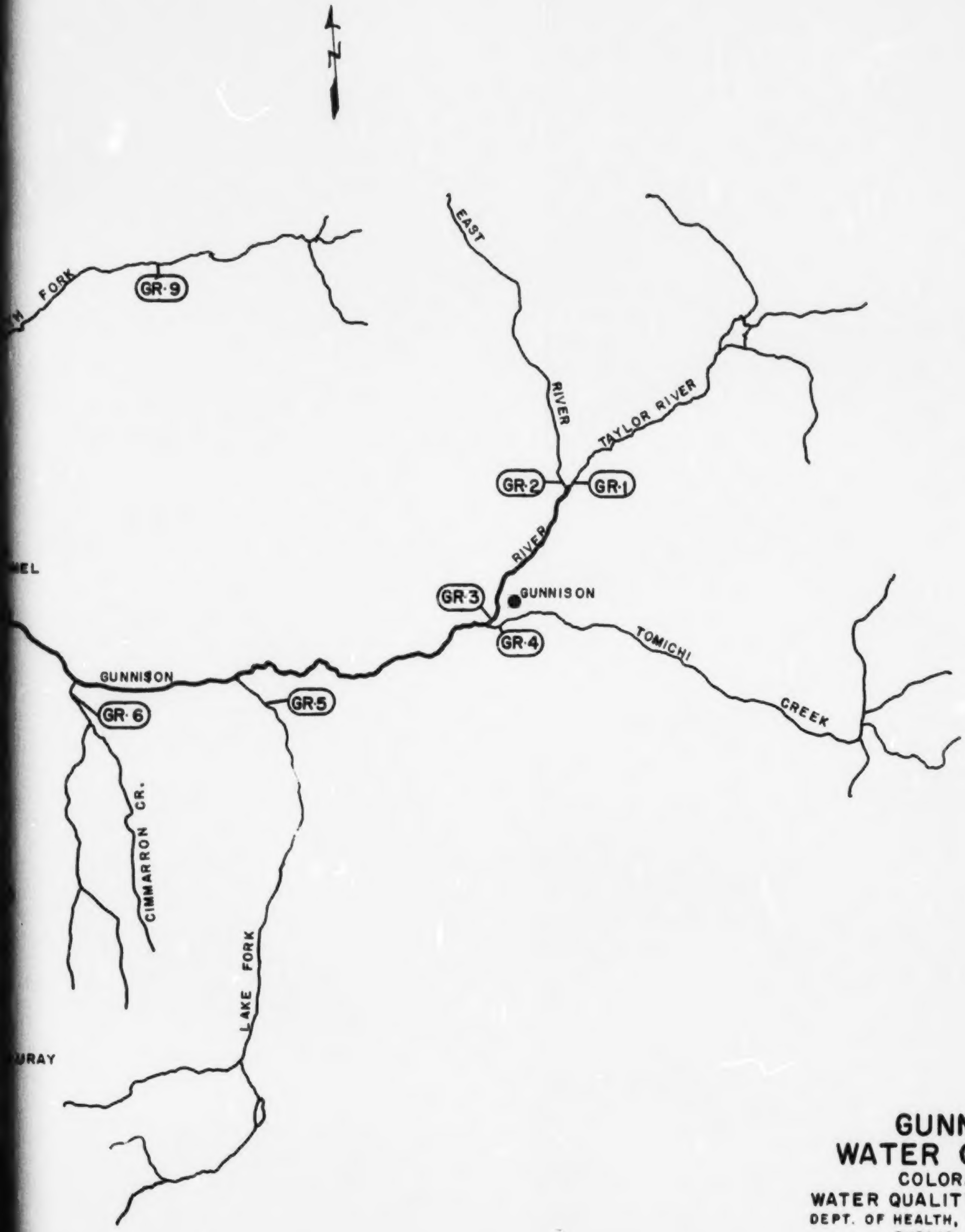
Total Dissolved Solids

GUNNISON RIVER BASIN WATER QUALITY STUDY

Aug 27 - Sept 8, 1962




GRAND JUNCTION
GR·22
GUNNISON
RIVER
GR·21
GR·19
GR·14
DELTA
GR·18
GR·20
CREEK
ROUBIDEAU
GR·12
GR·11
GR·10
GR·8
NORTH FORK
GR·9
GUNNISON TUNNEL
GR·7
MONTROSE
UNCOMPAHGRE
RIVER
GR·17
GR·16
OURAY
GR·15
GUNNISON
GR·6
GR·5
CIMMARRON CR.
LAKE FORK


N
FORK
GR·9
EAST
RIVER
TAYLOR RIVER
GR·2
GR·1
RIVER
GR·3
GUNNISON
GR·4
TOMICHI
CREEK
NEL
GUNNISON
GR·6
GR·5
CIMMARRON CR.
LAKE FORK
URAY

GUNNISON BASIN
WATER QUALITY STUDY

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

AUGUST & SEPTEMBER 1962

Activity: Grand Valley Area Water Quality Study

Purpose: Primary purposes of this study are the correlation of chemical loadings of the Colorado River Main Stem in the Grand Valley area during irrigation and non-irrigation seasons and the assessment of the effects of irrigation on water quality. This information will be used in development of the Upper Main Stem Water Quality Management Plan. Also, chemical, radiological, biochemical and bacteriological water quality data for the area are desired.

Summary of Progress:

Surveys have been run in the Grand Valley, Colorado area in August 1960, February-March 1962, and August 1962. Correlation of chemical loadings during these surveys which represent two irrigation and one non-irrigation season is now in the preliminary stages. Analysis of water quality is only partially completed.

The August 1960 survey was primarily a radiological study 1/ however, some useful chemical data was obtained. The February-March 1962 survey was designed to provide information on water quality during the non-irrigation season and covered the Colorado River from Cameo, Colorado (River Mile 1129) to below the Texas Gulf Sulfur Potash Plant below Moab, Utah (River Mile 974). The August 1962 survey was designed to cover the Grand Valley area during irrigation season. Samples were collected of main-stem and tributory waters from Cameo, Colorado to Westwater, Utah (River Mile 1056). In addition, a total of nineteen major irrigation return drains were sampled. These irrigation returns provided information on salinity contributions to the Colorado River from the irrigated acreages. A positive indication of greater chemical pollution during the irrigation season than during the non-irrigation season is shown by greater total dissolved solids increase during the August 1962 survey than the February-March 1962 survey. Flow during the August 1962 survey was slightly higher entering the survey area but approximately the same at the Westwater, Utah main stem station. It may be noted that during the August 1960 survey when river flow was less than half that during the August 1962 survey the total dissolved loading contributed was nearly the same as during the

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1/ Stream Studies in Vicinity of Uranium Mills. I. Area of Grand Junction, Colorado, August 1960 and II. Area of Moab, Utah, August 1960, U.S. Department of Health, Education, & Welfare, Public Health Service, Colorado River Basin Water Quality Control Project, Denver, Colorado.

Activity: Grand Valley Area Water Quality Study (continued)

August 1962 survey. Concentration of Total Dissolved Solids in the Colorado River during August 1960 was much higher than during the more recent survey as a result of the low flow.

Contributing sources of Total Dissolved Solids in the Grand Valley area entering the Colorado River are Plateau Creek, the Gunnison River including the Redlands Power Canal which is a diversion, dissolved solids picked up through irrigation return flows, and ground-water inflow and surface run-off along the Main Stem. Results of August 1962 showed the pickup measured in return drains was equal to the total contribution of the Gunnison River System. In addition, two-thirds of the amount measured in the return drains sampled was added to the river from other sources, primarily from unsampled, unmeasured irrigation return through seepage and small individual return drains.

Sulfate buildup in the area follows approximately the same pattern as Total Dissolved Solids with, however, even higher percentage increase within the river.

Chlorides follow a nearly level pattern through this area with an actual net loss from the upstream amount entering the system to that leaving the area.

In the light of the data at its present stage of development, Total Dissolved Solids are contributed heavily by the irrigated area, and in a significantly greater amount during the irrigation season. The same can be said of sulfate load relationships but with an even greater percentage increase than the Total Dissolved Solids. Chlorides, on the other hand, are significant by the fact of their stability in the area.

Future Plans:

In the remainder of Fiscal Year 1963, analysis of data from both surveys will continue with relation to relative chemical buildup in the irrigated area along the river.

In Fiscal Year 1964, one or more reports will be issued concerning the study and correlating the results from the surveys.

GRAND VALLEY AREA STUDY

Total Dissolved Solids
Mean Concentrations and Loadings

River Mile	August 1960		Feb.-March 1962		August 1962	
	mg/1	10^3#/day	mg/1	10^3#/day	mg/1	10^3#/day
1129	----	----	523	6263	464	7977
1123	----	----	400	218	---	----
1107	----	----	576	7195	500	4804
1102	----	----	---	----	---	----
1101	1340	2430	---	----	606	6252
1098	1380	2920	---	----	---	----
1097	----	----	---	----	842	9101
1086	----	----	693	11494	823	13140
1081	----	----	732	12232	907	15898
1056	----	----	764	13502	881	16137
1025	1835	13220	785	14050	---	----
1018	1845	13850	---	----	---	----
993	----	----	862	16879	---	----
991	1835	13720	---	----	---	----
988	1845	13810	---	----	---	----
986	----	----	821	16087	---	----
981	1835	13765	---	----	---	----
974	----	----	830	16238	---	----

Sulfate Mean Concentrations and Loadings

River Mile	August 1960		Feb.-March 1962		August 1962	
	mg/1	10^3#/day	mg/1	10^3#/day	mg/1	10^3#/day
1129	----	----	135	1614	114	1957
1123	----	----	97	53	---	----
1107	----	----	166	2074	143	1372
1102	470	921	---	----	---	----
1101	540	1066	---	----	216	2232
1098	525	1390	---	----	---	----
1097	---	----	250	3155	361	4082
1086	---	----	290	4812	385	6149
1081	---	----	310	5177	434	7612
1056	890	6590	335	5927	429	7871
1025	874	6285	332	5949	---	----
1018	877	6560	---	----	---	----
993	---	----	337	6594	---	----
991	849	6350	---	----	---	----
988	---	----	---	----	---	----
986	---	----	340	6665	---	----
981	843	6310	---	----	---	----
974	---	----	326	6392	---	----

GRAND VALLEY AREA STUDY

Chlorides
Mean Concentrations and Loadings

River Mile	August 1960 mg/l	August 1960 10^3#/day	Feb.-March 1962 mg/l	Feb.-March 1962 10^3#/day	August 1962 mg/l	August 1962 10^3#/day
1129	----	----	136	1630	111	1908
1123	----	----	---	----	---	----
1107	----	----	138	1731	107	1032
1102	110	216	---	----	---	----
1101	115	227	---	----	116	1198
1098	115	304	---	----	---	----
1097	---	---	129	1632	126	1418
1086	---	---	105	1740	90	1444
1081	---	---	113	1883	94	1642
1056	85	634	106	1882	91	1666
1025	86	620	100	1785	--	----
1018	107	767	---	----	--	----
993	---	---	145	2848	--	----
991	101	760	---	----	--	----
988	105	790	---	----	--	----
986	---	---	147	2889	--	----
981	108	816	---	----	--	----
974	---	---	137	2660	--	----

Contributing Sources of Chemical Constituents

August 1962 Contribution 10^3#/day

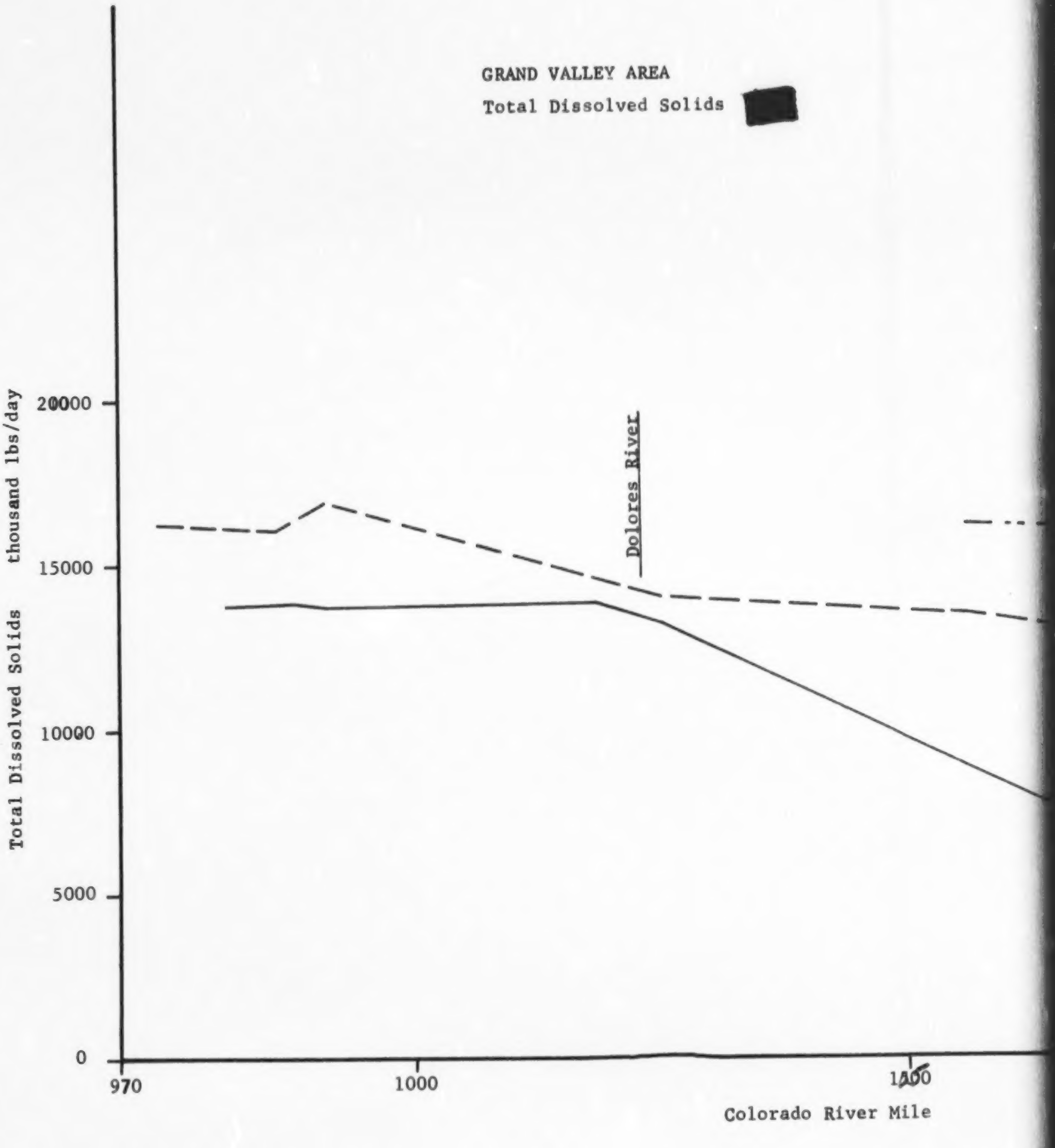
	TDS	$SO_4^=$	Cl^-
Colorado River	7977	1957	1908
Plateau Creek	154	37	3
Gunnison River (includes Redlands Power Canal)	4183	2516	69
Measured Irrigation Return Flows	4721	2406	367
Palisade Vicinity Diversions	-3929	-962	-945
Total Measured Contribution	13111	5954	1402
Total at River Mile 1056	16137	7871	1666
Unmeasured Contribution	3026	1917	264

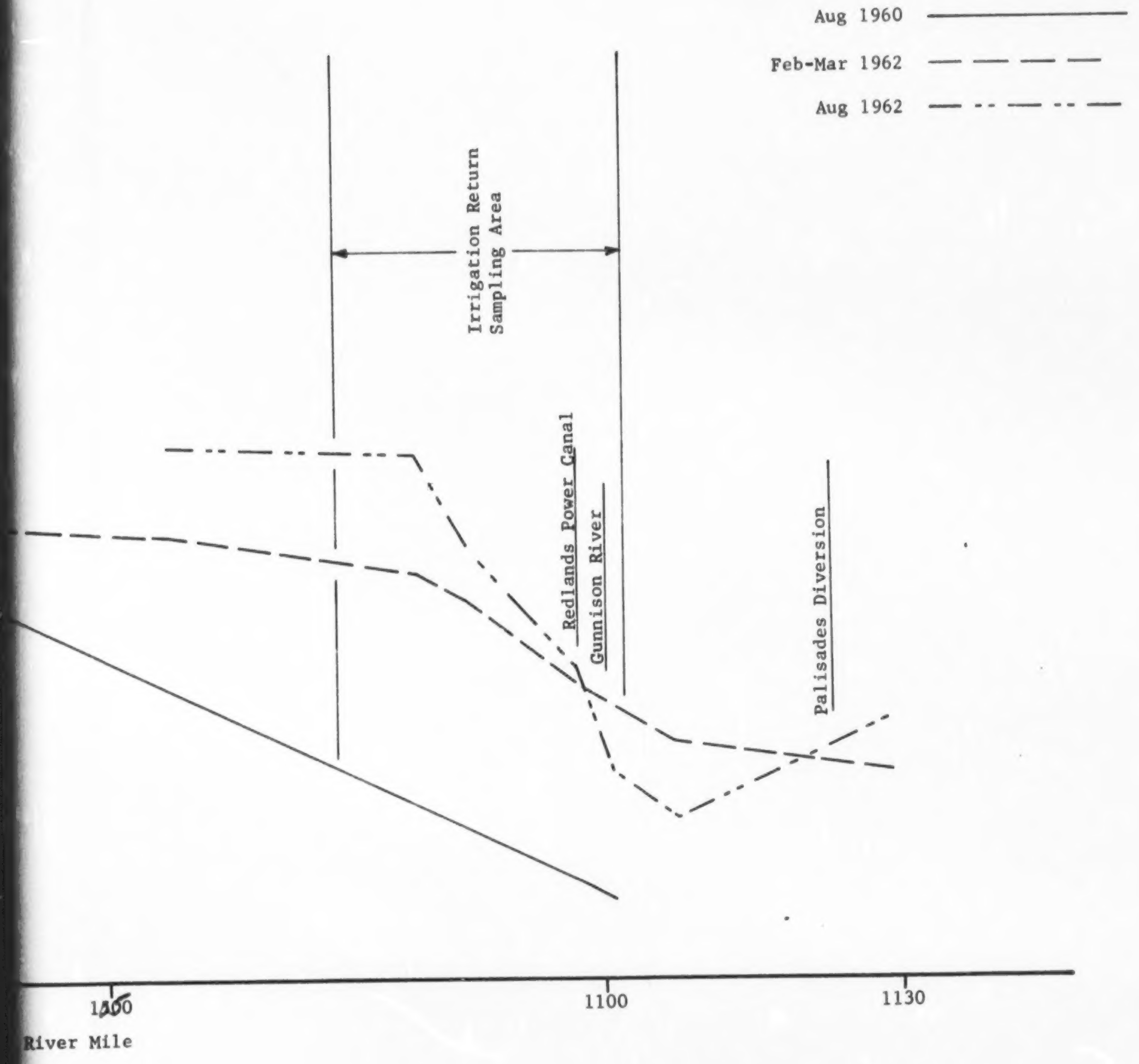
GRAND VALLEY AREA STUDY

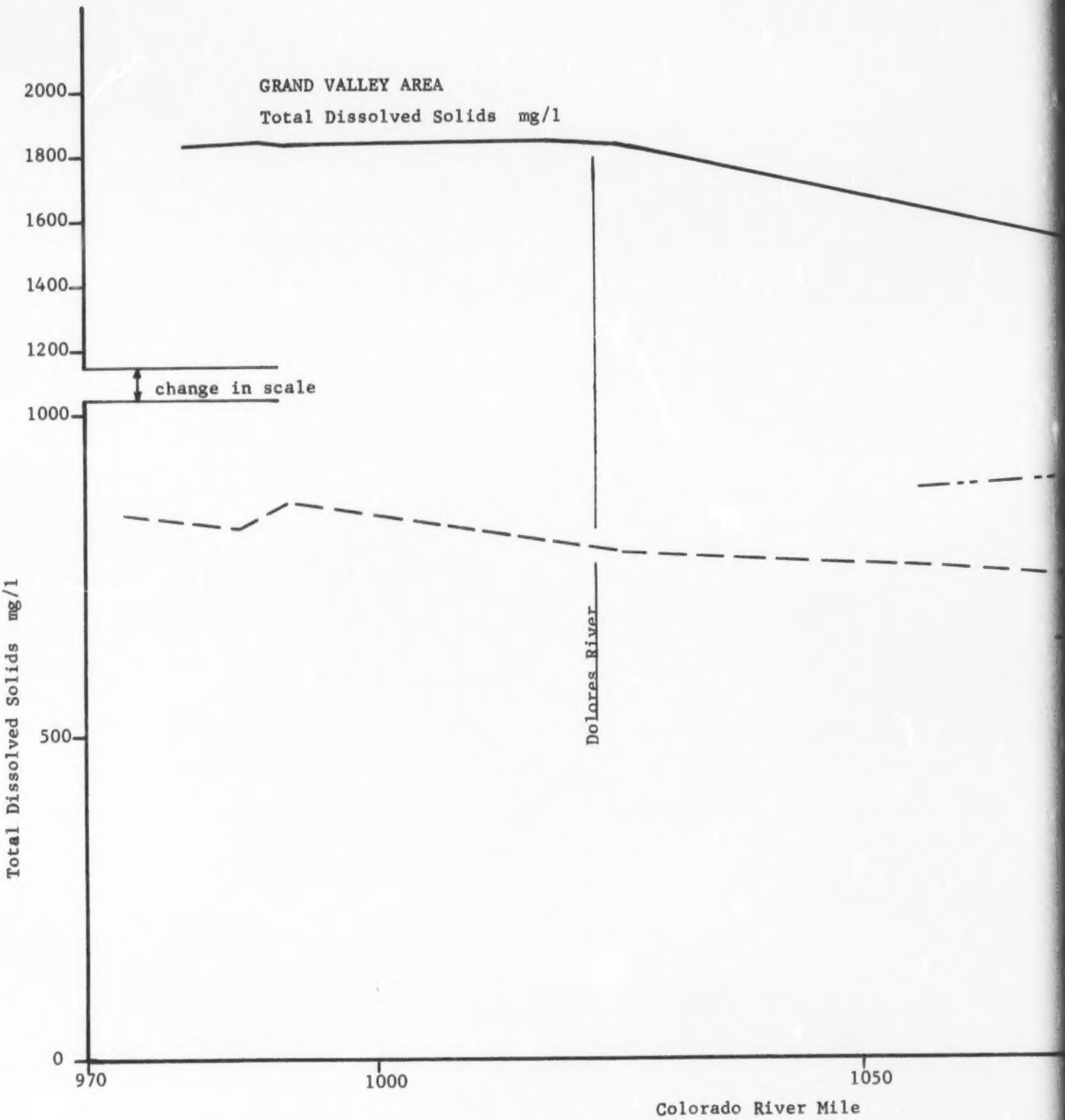
August 1962

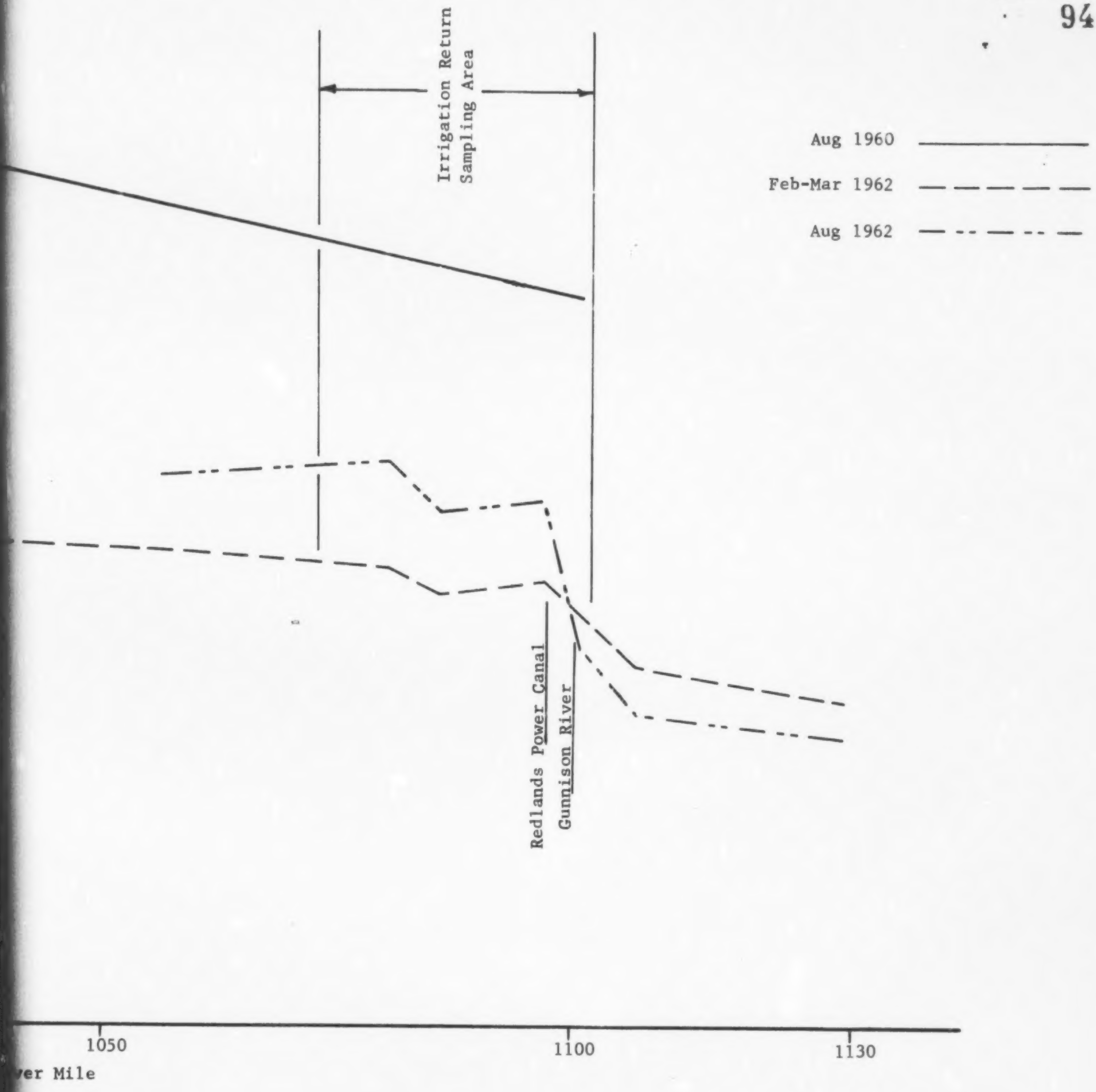
Irrigation Return Flows

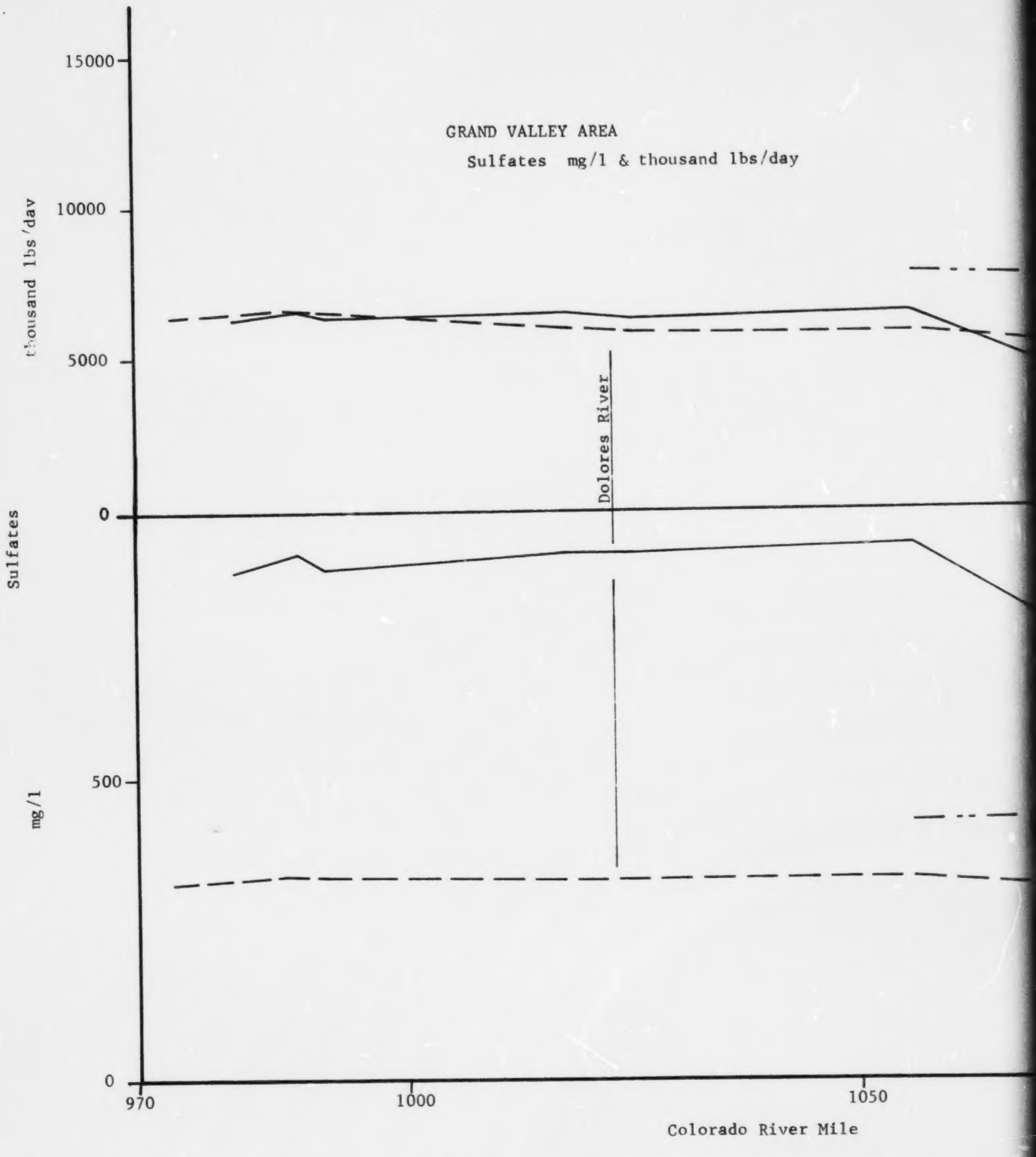
Station Number	River Mile	Flow cfs	TDS 10^3 #/day	Cl^- 10^3 #/day	$SO_4^=$ 10^3 #/day
I-1	1101.6	3.5	40.22	5.00	22.06
I-2	1100.4	8.4	95.50	7.90	53.40
I-3	1098.3	2.9	38.40	3.00	22.10
I-4	1098.2	12.85	79.75	11.00	37.60
I-5	1097.3	41.85	340.70	30.80	175.20
I-6	1093.1	3.30	16.00	2.12	6.26
I-7	1091.8	43.00	345.00	30.00	165.00
I-8	1091.2	18.30	129.00	11.80	61.00
I-9	1090.9	35.60	315.00	24.90	158.00
I-10	1088.2	30.20	257.00	21.00	125.00
I-11	1084.9	30.80	221.00	21.20	102.00
I-12	1084.6	64.00	711.00	46.60	369.00
I-13	1082.4	114.90	1183.00	83.60	619.00
I-14	1082.1	17.40	50.60	9.00	15.70
I-15	1073.4	16.10	195.00	12.30	104.00
I-16	1073.4	9.20	131.00	7.24	71.90
I-17	1073.4	27.10	316.00	19.90	166.00
I-18	1073.4	15.70	152.00	11.30	80.10
I-19	1082.4	12.20	105.00	8.35	52.60
	Total	507.3	4721.2	367.0	2405.9

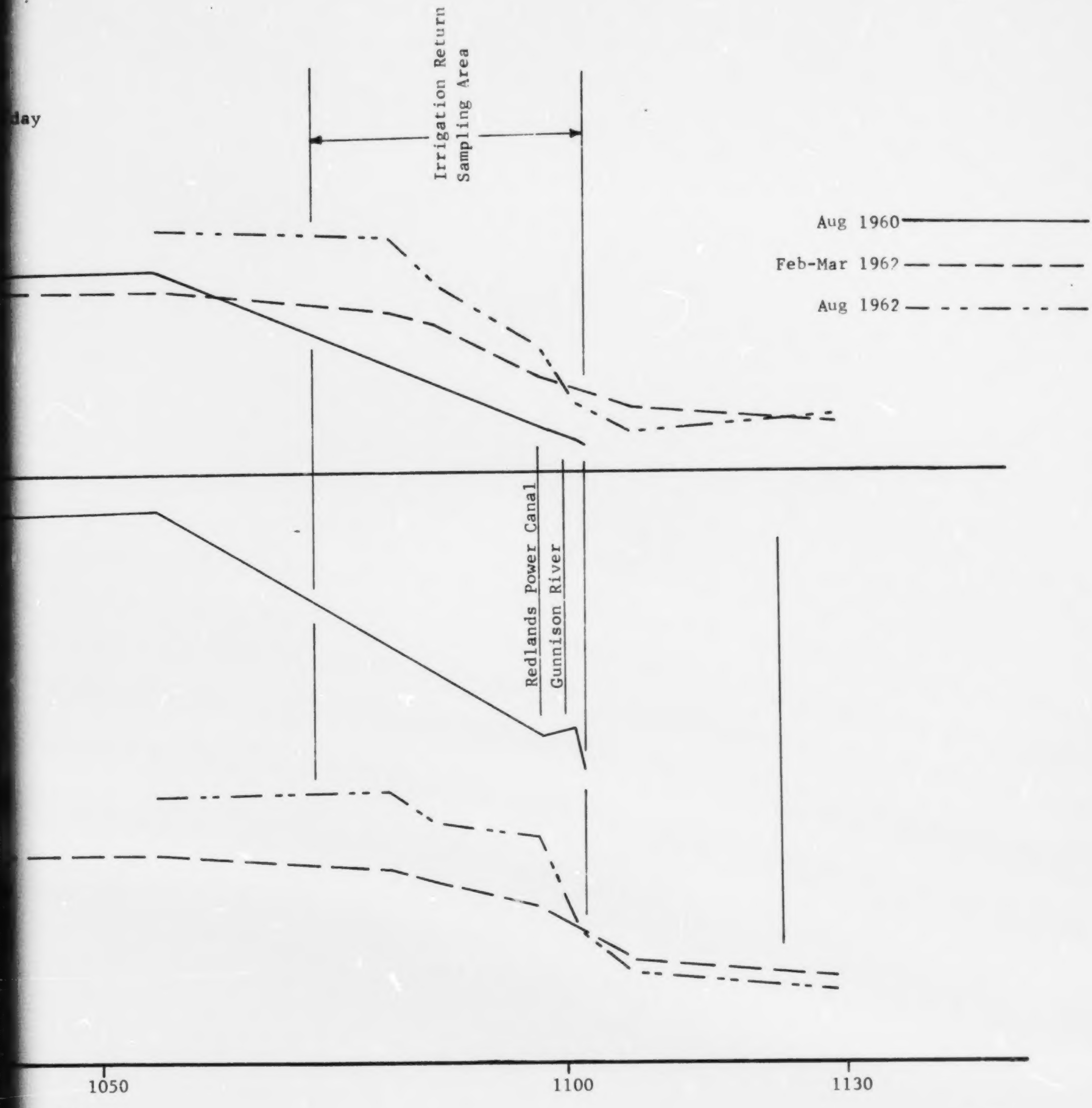

GRAND VALLEY AREA
Total Dissolved Solids
Total Dissolved Solids thousand lbs/day
20000
15000
10000
5000
0
Dolores River
970
1000
1100
Colorado River Mile


Aug 1960
Feb-Mar 1962
Aug 1962
Irrigation Return
Sampling Area
Redlands Power Canal
Gunnison River
Palisades Diversion
1050
1100
1130
River Mile

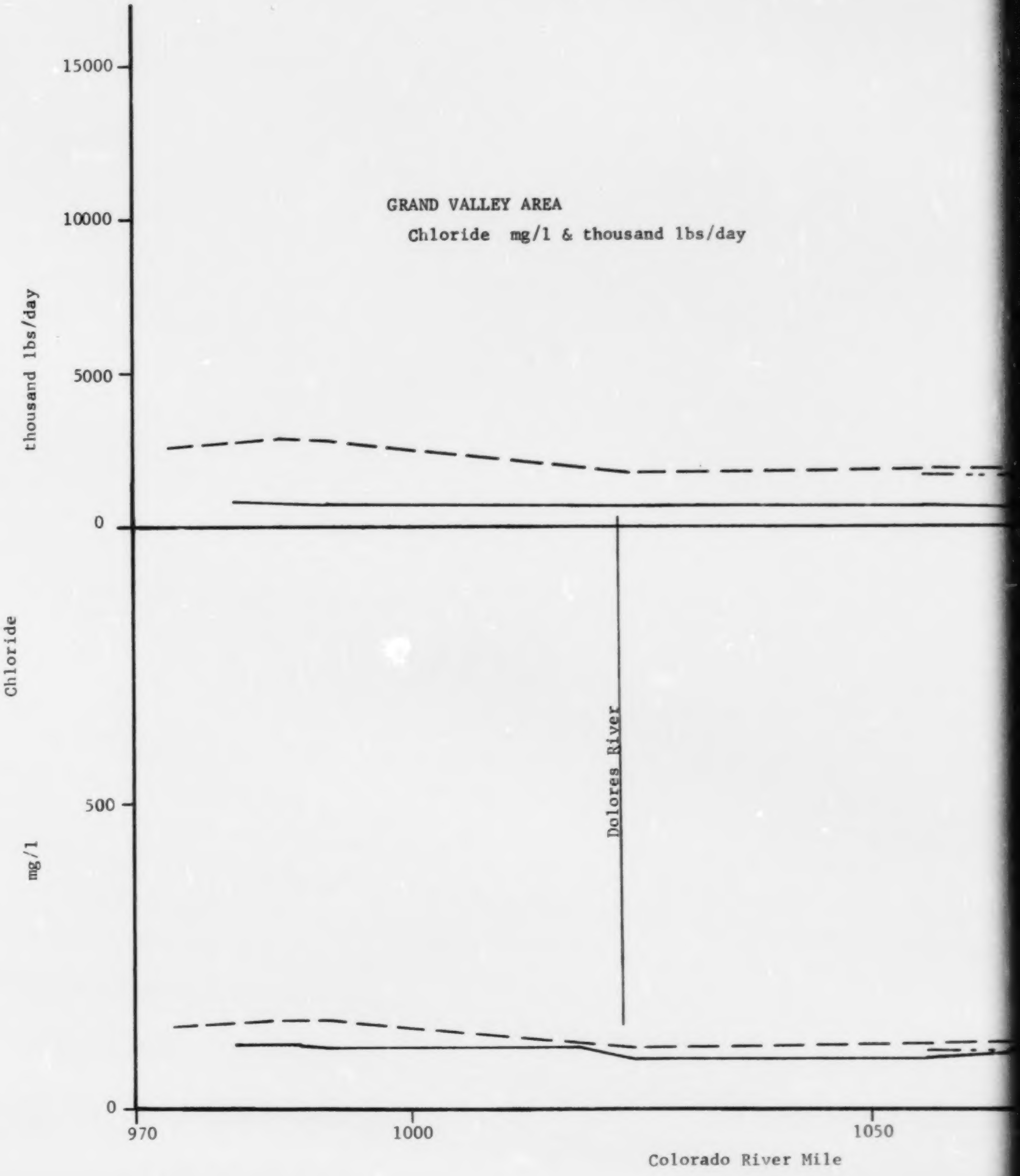

GRAND VALLEY AREA
Total Dissolved Solids mg/l
2000
1800
1600
1400
1200
change in scale
1000
500
0
Total Dissolved Solids mg/l
Dolores River
970
1000
1050
Colorado River Mile

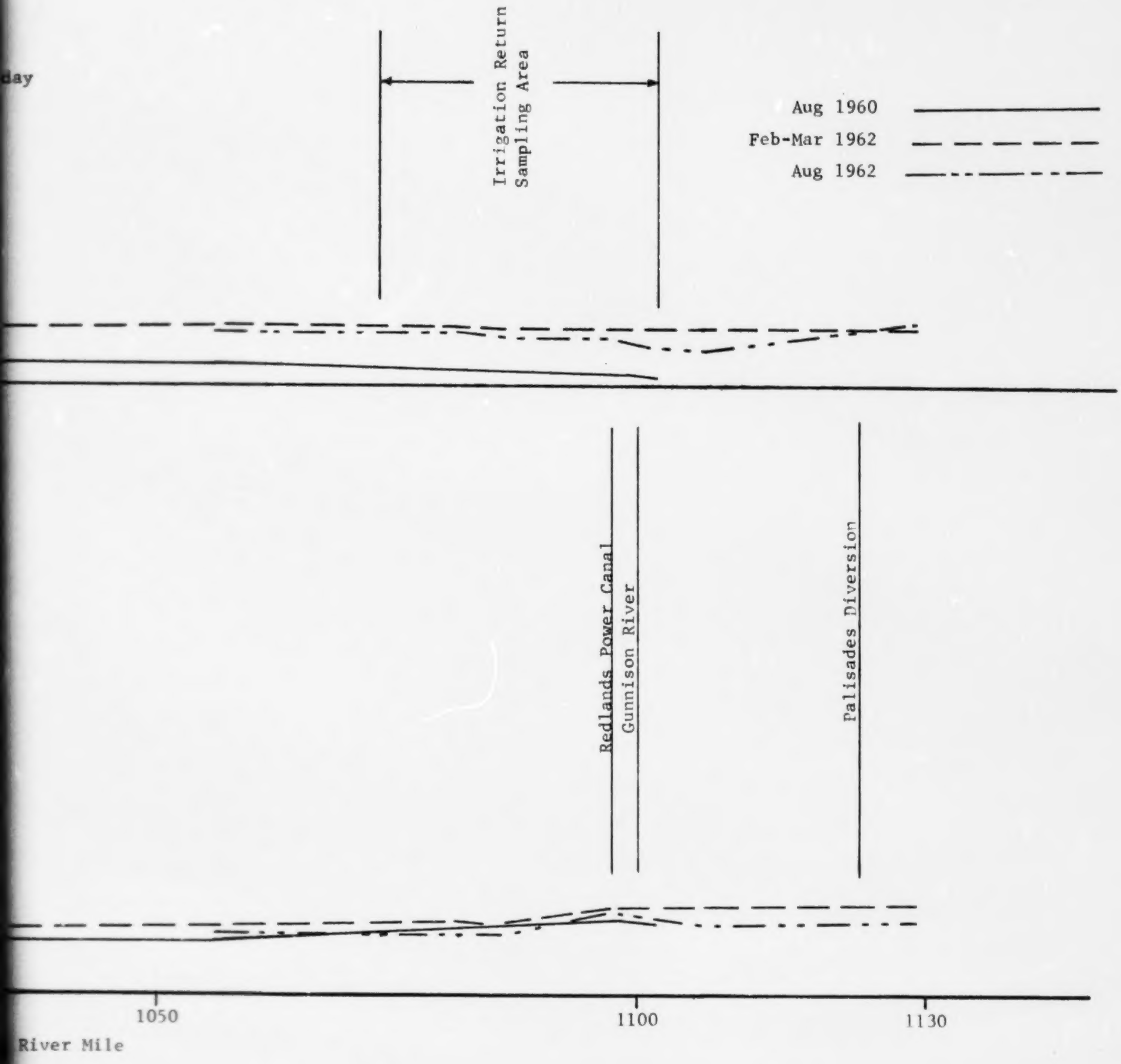

Irrigation Return
Sampling Area
Aug 1960
Feb-Mar 1962
Aug 1962
Redlands Power Canal
Gunnison River
1050
1100
1130
ver Mile

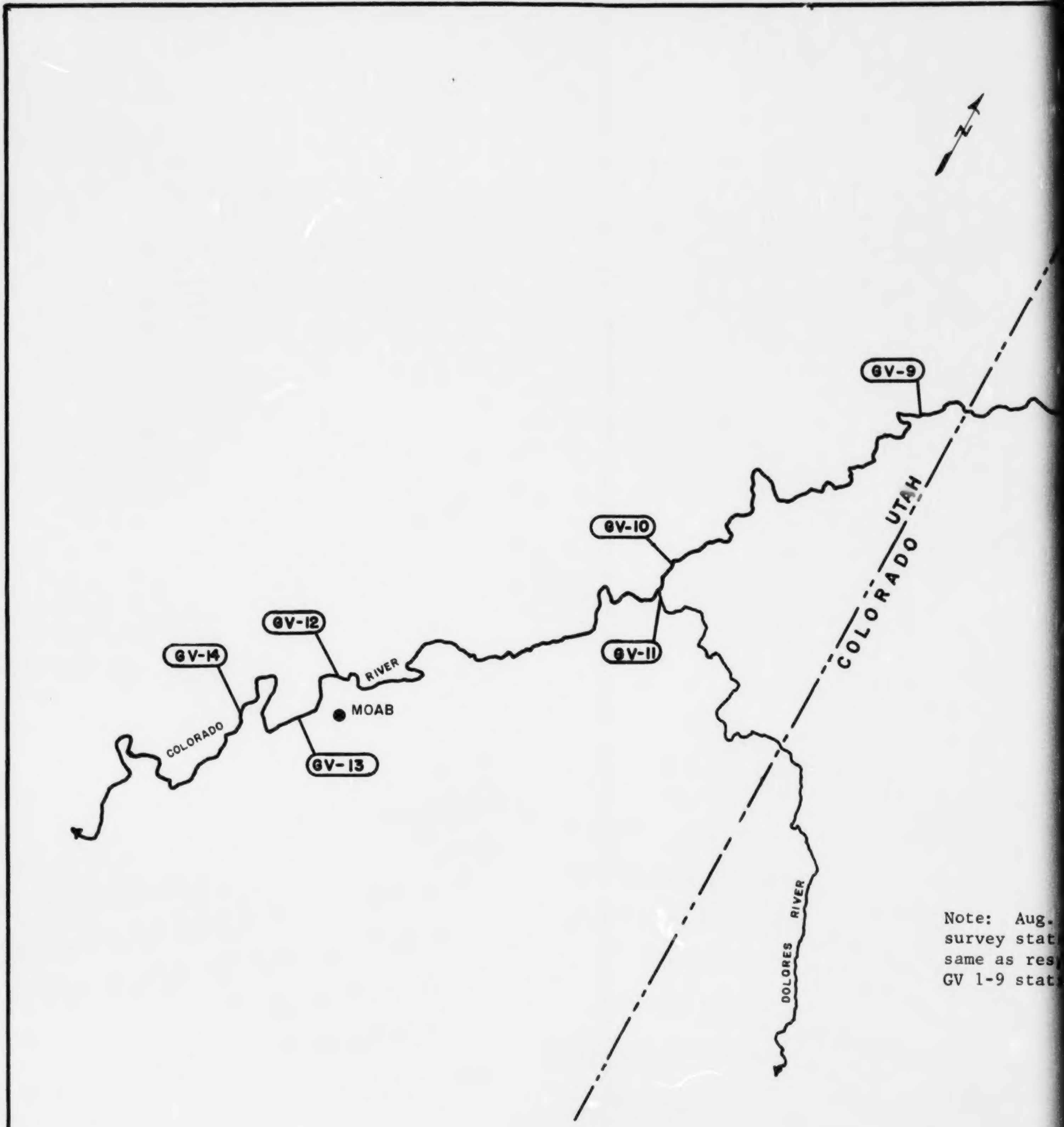

GRAND VALLEY AREA
Sulfates mg/l & thousand lbs/day
15000
10000
5000
0
500
0
thousand lbs/day
Sulfates
mg/l
Dolores River
970
1000
1050
Colorado River Mile


Irrigation Return
Sampling Area
day
Aug 1960
Feb-Mar 1962
Aug 1962
Redlands Power Canal
Gunnison River
1050
1100
1130
ver Mile

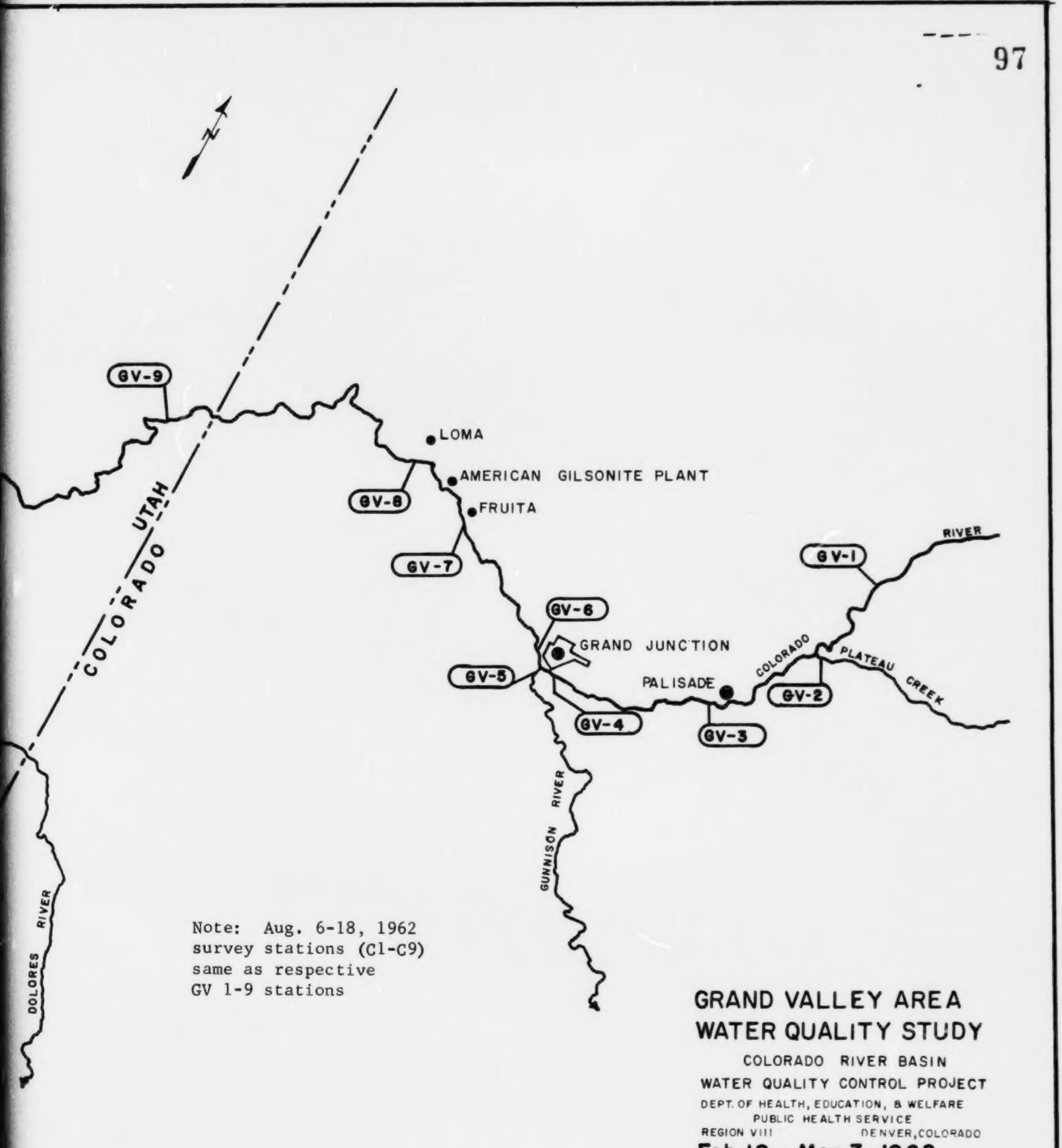
GPO 831097


GRAND VALLEY AREA
Chloride mg/l & thousand lbs/day
thousand lbs/day
15000
10000
5000
0
Chloride
mg/l
500
0
Dolores River
970
1000
1050
Colorado River Mile


day
Irrigation Return
Sampling Area
Aug 1960
Feb-Mar 1962
Aug 1962
Redlands Power Canal
Gunnison River
Palisades Diversion
1050
1100
1130
River Mile


N
GV-9
GV-10
GV-11
GV-12
GV-13
GV-14
MOAB
RIVER
COLORADO
UTAH
COLORADO
DOLORES
RIVER

Note: Aug.
survey stat
same as res
GV 1-9 stat

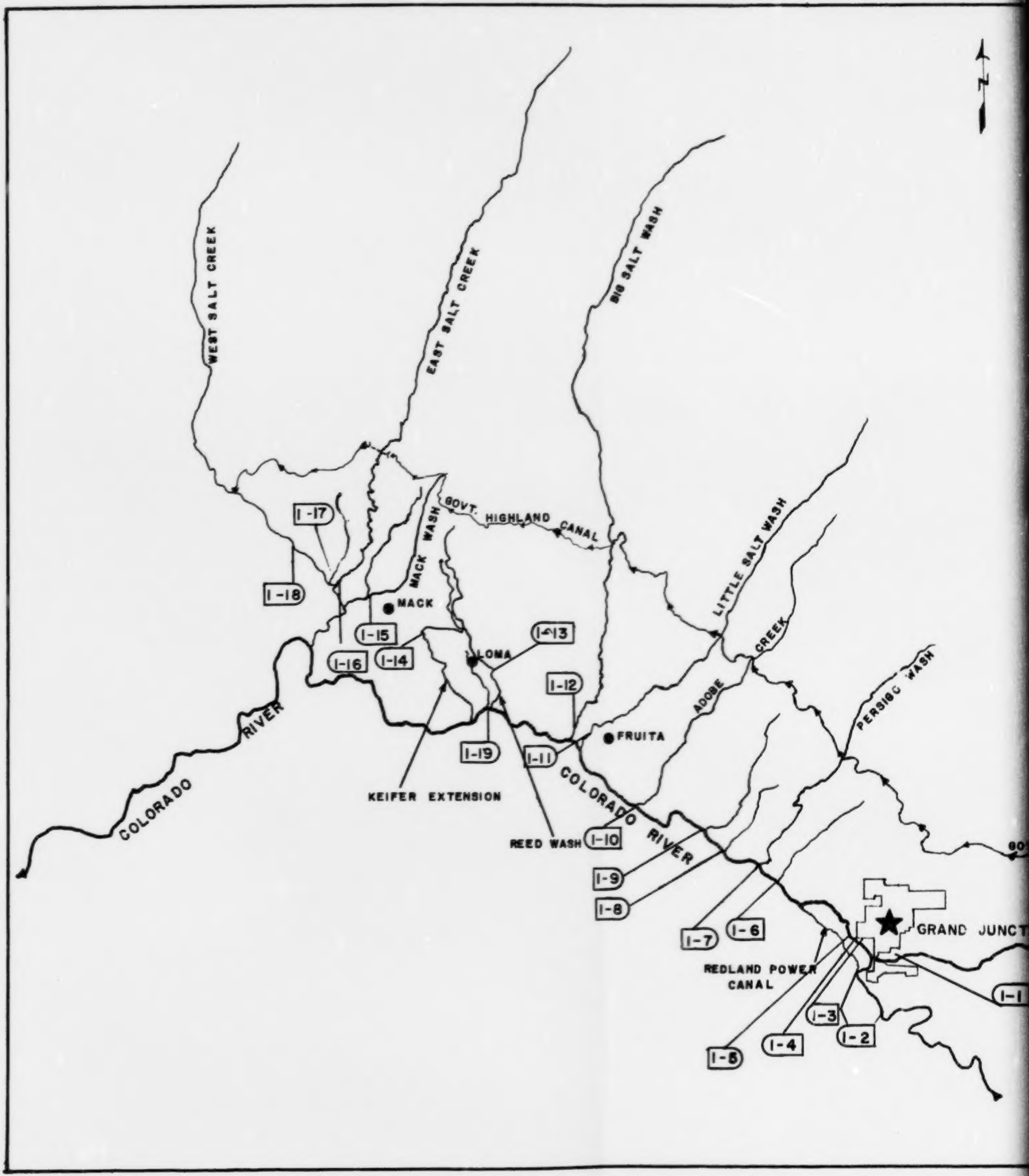

N
UTAH
COLORADO
GV-9
LOMA
AMERICAN GILSONITE PLANT
GV-8
FRUITA
GV-7
RIVER
GV-1
GV-6
GRAND JUNCTION
COLORADO
PLATEAU CREEK
GV-5
PALISADE
GV-2
GV-4
GV-3
GUNNISON RIVER
DOLORES RIVER

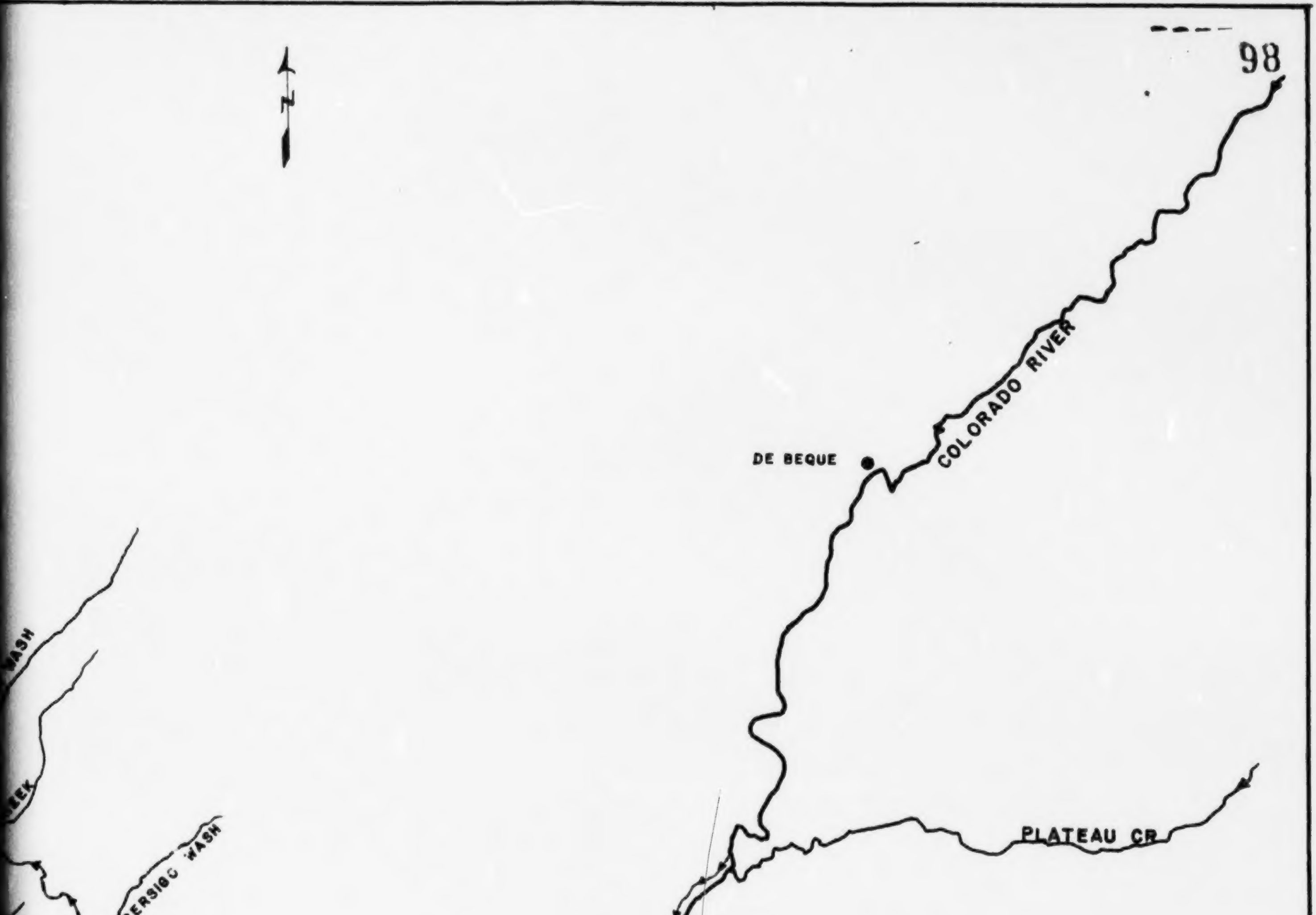
Note: Aug. 6-18, 1962
survey stations (C1-C9)
same as respective
GV 1-9 stations

GRAND VALLEY AREA WATER QUALITY STUDY

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

Feb. 19 – Mar. 3, 1962


N
WEST SALT CREEK
EAST SALT CREEK
BIG SALT WASH
GOVT. HIGHLAND CANAL
MACK WASH
LITTLE SALT WASH
ADOBE CREEK
PERSIGO WASH
MACK
LOMA
FRUITA
COLORADO RIVER
COLORADO RIVER
KEIFER EXTENSION
REED WASH
REDLAND POWER CANAL
GRAND JUNCT
GOV
1-1
1-2
1-3
1-4
1-5
1-6
1-7
1-8
1-9
1-10
1-11
1-12
1-13
1-14
1-15
1-16
1-17
1-18
1-19


N
COLORADO RIVER
DE BEQUE
PLATEAU CR
CAMEO
GOVT. HIGHLAND CANAL
PERSIGO WASH
WASH
EEK
GRAND JUNCTION
POWER
1-1
1-3
1-2
-4

GRAND VALLEY AREA
WATER QUALITY STUDY
August-September 1962

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT
DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

Activity: Study of Stratification and Chemical Conditions in Two Selected Reservoirs.

Purpose: The reservoir studies were conducted to obtain information on chemical conditions and the extent of chemical, thermal and dissolved oxygen stratification existing in these two reservoirs. The Project will be assisted in evaluation of proposed reservoirs in relation to reservoir construction, flow regulation and pollution control studies. The data obtained will also be used in the preparation of the Upper Main-Stem water quality management plan.

Summary of Progress:

Short-term studies were conducted during August, 1962 on Taylor Park Reservoir and Lake Granby, located in the Upper Main-Stem Sub-Basin. Samples were taken at various locations and depths over a three-day period on each reservoir. Temperatures and dissolved oxygen determinations were made, together with pH, alkalinity, conductivity, and BOD.

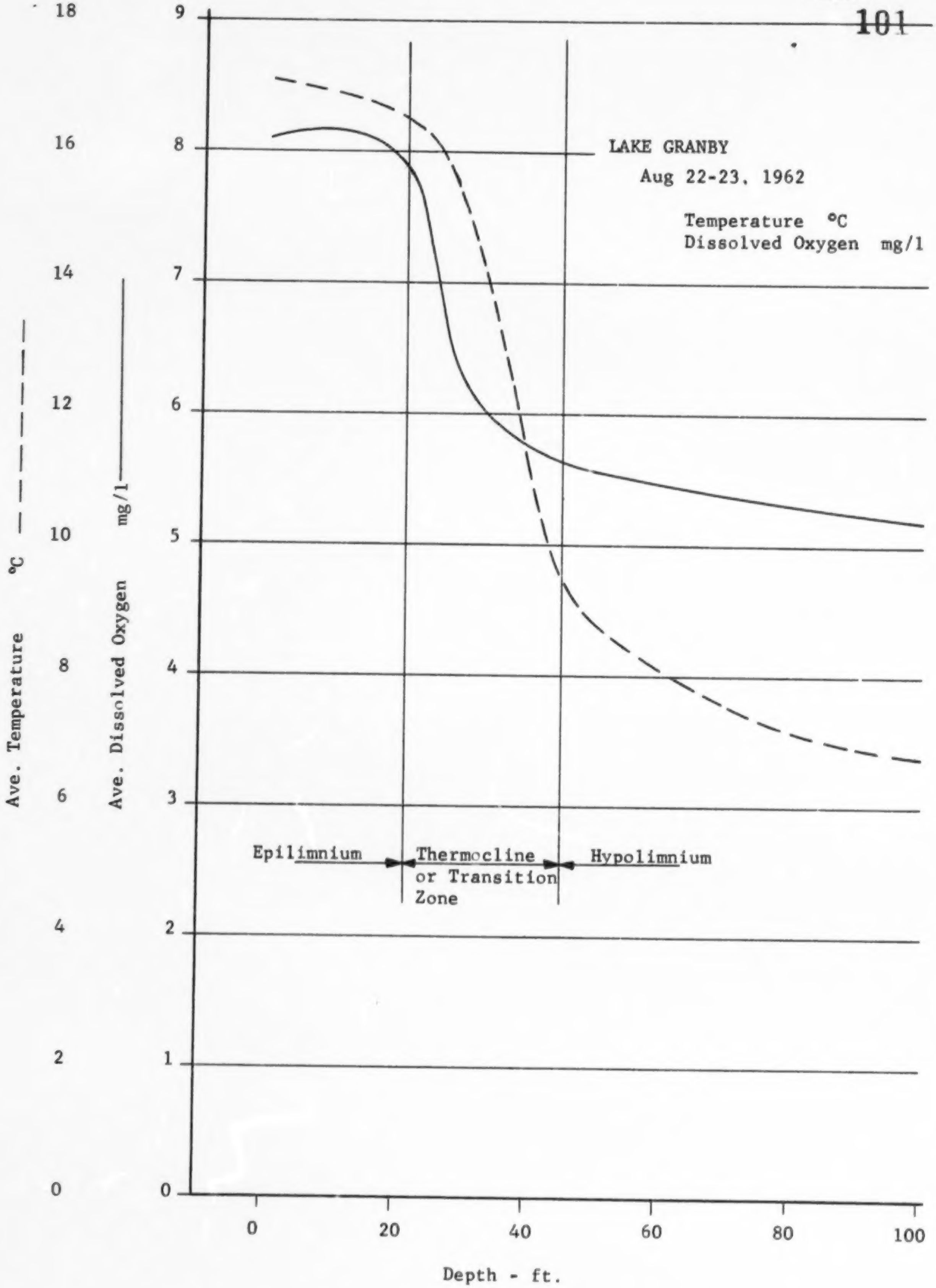
Moderate thermal and DO stratification was evident in each reservoir as indicated in the accompanying table and graphs.

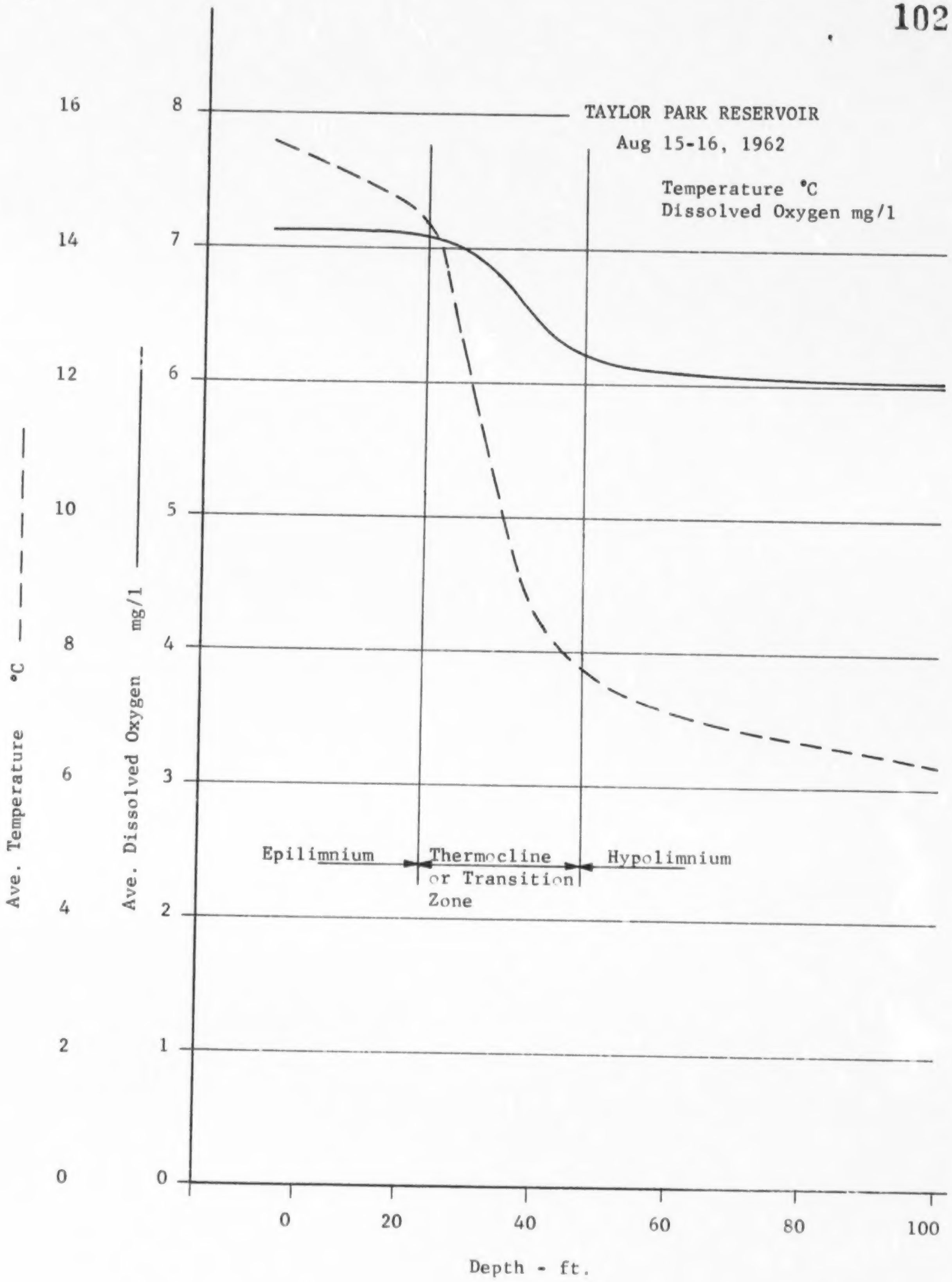
Future Plans:

A report covering the two reservoirs studied is in the first stage of development and will be completed during the first half of FY 1964. Upon further analysis of the results from these two reservoirs, a decision will be made concerning the desirability of similar studies on additional reservoirs in the Basin.

Study of Stratification and Chemical Conditions in Selected Reservoirs

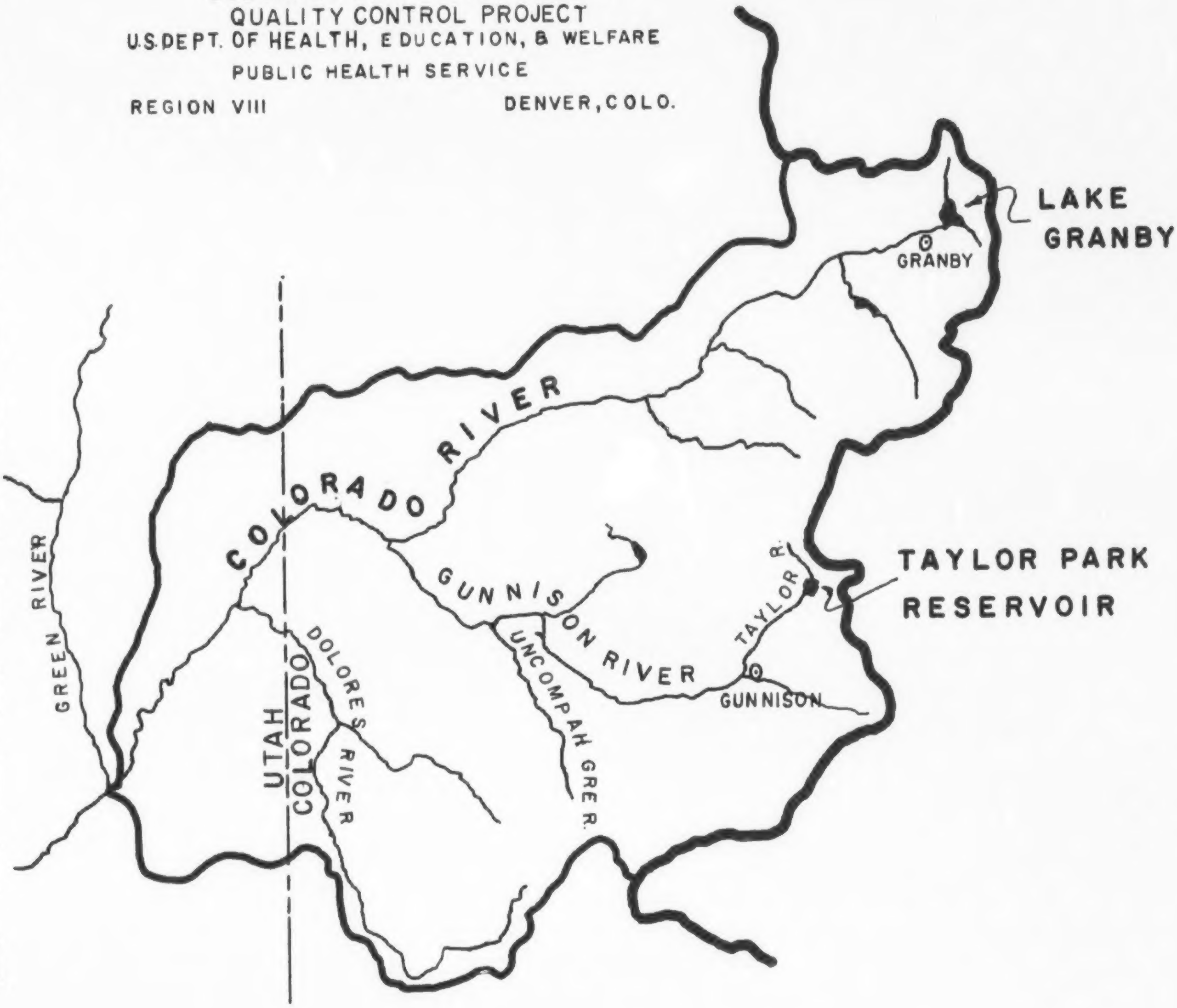
	Lake Granby (Elev. 8280) August 22-23, 1962		Taylor Park Reservoir (Elev. 9330) August 15-16, 1962	
Depth Feet	Temperature Average °C	Dissolved Oxygen Average mg/1	Temperature Average °C	Dissolved Oxygen Average mg/1
0	17.1	8.1	15.5	7.3
5	17.0		15.4	
10	16.9	8.2	15.0	7.3
20	16.6	7.9	14.7	7.2
30	15.1	6.1	12.0	6.9
40	11.2		8.5	
50	8.8	5.4	7.5	6.1
60	8.1		7.2	
70	7.5	5.3	6.9	6.2
80	7.1		6.7	
90	6.9		6.5	
100	6.7	5.2	6.4	6.1


LAKE GRANBY
Aug 22-23, 1962
Temperature °C
Dissolved Oxygen mg/1
Ave. Temperature °C
Ave. Dissolved Oxygen mg/1
18
16
14
12
10
8
6
4
2
0
9
8
7
6
5
4
3
2
1
0
Epilimnium
Thermocline or Transition Zone
Hypolimnium
0
20
40
60
80
100
Depth - ft.


TAYLOR PARK RESERVOIR
Aug 15-16, 1962
Temperature °C
Dissolved Oxygen mg/1
Ave. Temperature °C
Ave. Dissolved Oxygen mg/1
16
14
12
10
8
6
4
2
0
8
7
6
5
4
3
2
1
0
Epilimnium
Thermocline or Transition Zone
Hypolimnium
0
20
40
60
80
100
Depth - ft.

UPPER MAIN-STEM
SUB-BASIN
OF THE
COLORADO RIVER BASIN

COLORADO RIVER BASIN WATER
QUALITY CONTROL PROJECT
U.S. DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII
DENVER, COLO.


LAKE GRANBY
GRANBY
COLORADO RIVER
GREEN RIVER
GUNNISON RIVER
TAYLOR R.
TAYLOR PARK RESERVOIR
GUNNISON
UNCOMPAHGRE R.
DOLORES RIVER
UTAH
COLORADO

Activity: Water Quality Network in Upper Main-Stem.

Purpose: To fill data gaps in USGS water quality data in order to assist in relating changes in salinity to causes.

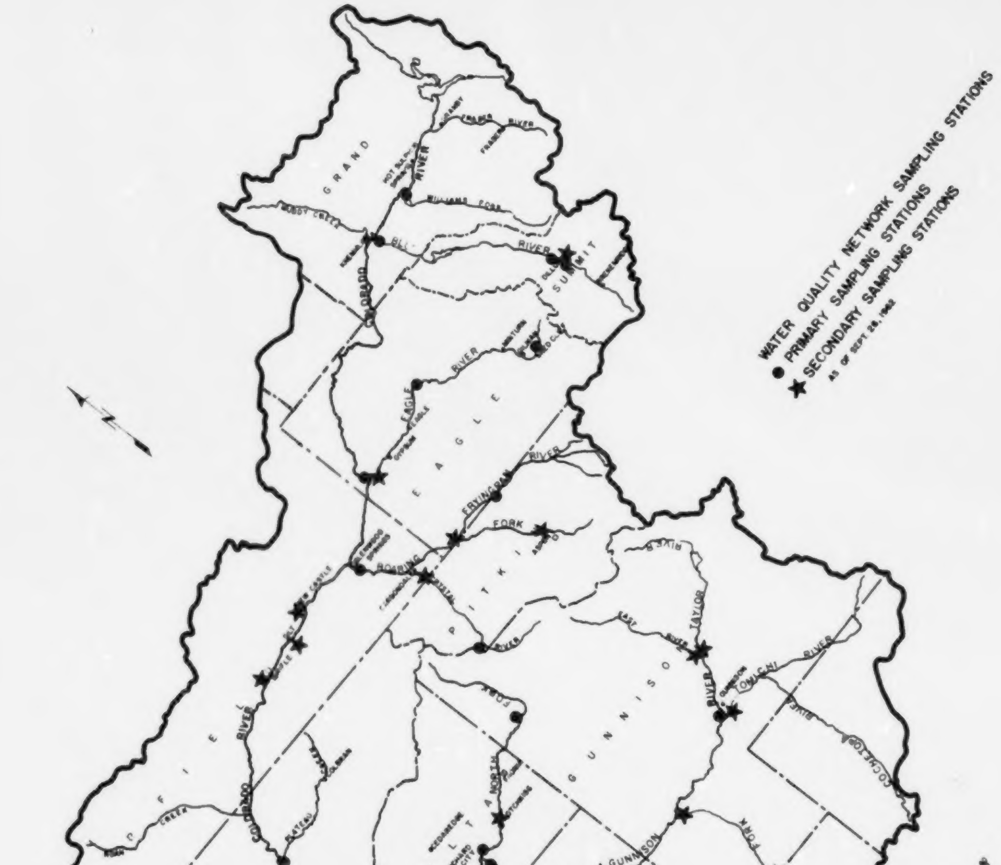
Summary of Progress:

Grab samples were taken at about 22 primary locations once a month since July 1962. (See attached map). In addition, field conductivities were obtained at about 20 other secondary locations. Results are just beginning to arrive.

Future Plans:

Collection of samples are planned for February and May.

Officially ask for Grand Valley & Eden Proj data?


WATER QUALITY NETWORK SAMPLING STATIONS
● PRIMARY SAMPLING STATIONS
★ SECONDARY SAMPLING STATIONS
AS OF SEPT 26, 1962
N
GRAND
SUMMIT
EAGLE
PITKIN
GARFIELD
MESA
DELTA
GUNNISON
MONTROSE
OURAY
SAN MIGUEL
DOLORES
SAN JUAN
GRAND
UTAH
COLORADO
COLORADO RIVER
FRASER RIVER
WILLIAMS FORK
BLUE RIVER
EAGLE RIVER
ROARING FORK
FRYINGPAN RIVER
CRYSTAL RIVER
PLATEAU CREEK
GUNNISON RIVER
TAYLOR RIVER
EAST RIVER
TOMICHI RIVER
COCHETOPA
LAKE FORK
NORTH FORK
UNCOMPAHGRE RIVER
SAN MIGUEL RIVER
DOLORES RIVER
GRAND JUNCTION
LAKE CITY

COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

UPPER MAIN STEM

DEPT. OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VIII DENVER, COLORADO

Dissolved Oxygen and pH Field Data
Upper Main-Stem Water Quality Network

Primary Station Location	Date	Time	Temp. °C	Dissolved Oxygen, ppm	pH
Williams Fork River below Williams Fork Reservoir	10-22-62	1050	8.5	2.4	6.8
	12- 3-62	1205	5.0	7.4	
Tenmile Creek at mouth near Dillon	10-22-62	1245	8.2	8.6	7.5
Blue River downstream confluence Snake & Tenmile Creek at Dillon	10-22-62	1225	7.0	8.8	7.5
Blue River near mouth	10-22-62	1135	11.0	8.4	7.7
Colorado River above Eagle River	10-22-62	1550	10.0	10.2	8.1
Eagle River at Redcliff	10-22-62	1420	8.0	8.5	8.0
Eagle River above Wolcott	10-22-62	1505	9.7	9.2	8.0
Frying Pan River at Ruedi	10-23-62	1015	3.8	10.3	8.5
Crystal River at Placita	10-23-62	1140	7.1	9.7	7.1
Roaring Fork River at mouth	10-22-62	1625	10.5	9.6	8.0
Plateau Creek at Mouth	10-23-62	1440	11.0	10.7	8.5
Gunnison River at Gunnison	10-26-62	1005	5.0	10.4	7.8
Gunnison River above North Fork	10-25-62	1030	8.7	11.0	7.9
North Fork Gunnison River, 2 mi. East of Somerset	10-25-62	0920	5.2	10.6	7.9
North Fork Gunnison River at mouth	10-25-62	1020	9.0	11.2	8.2
Gunnison River upstream of Delta	10-25-62	1120	9.0	10.0	7.9
Uncompahgre River at Ouray	10-25-62	1420	6.0	9.6	6.8
Uncompahgre River near Ridgeway	10-25-62	1325	12.0	9.8	7.8
Uncompahgre River near mouth	10-25-62	1130	10.0	10.0	8.1
Gunnison River off Escalante Canyon Road	10-24-62	1645	12.0	8.2	8.2
Colorado River at Westwater, Utah	10-24-62	1010	12.5	9.2	8.0
Dolores River below Rico	9-26-62	1250	8.8		7.2

Dissolved Oxygen and pH Field Data
Upper Main-Stem Water Quality Network

Secondary Station Location	Date	Time	Temp. °C	Dissolved Oxygen, ppm	pH
Snake Creek at mouth near Dillon	10-22-62	1240	8.0	8.8	7.4
Eagle River at mouth	10-22-62	1540	9.7	9.8	8.0
Roaring Fork River above Aspen	10-23-62	0915	4.0	9.5	8.0
Frying Pan River at mouth	10-23-62	1045	6.5	10.6	
Crystal River 4 miles above mouth at Fish Hatchery	10-23-62	1115	7.3	10.1	7.8
Elk Creek near mouth	10-23-62	1310	12.0	9.0	8.2
Divide Creek near mouth	10-23-62	1330	13.0	15.2 (algae effect)	8.5
Rifle Creek at mouth	10-23-62	1350	12.8	8.9	8.3
Taylor River at mouth	10-26-62	1045	4.0	10.6	8.2
East River at mouth	10-26-62	1040	5.0	10.0	8.2
Tomichi Creek at Gunnison	10-26-62	1015	5.0	9.8	8.2
Lake Fork Gunnison River at mouth	10-26-62	0920	3.3	10.4	7.9
Cimarron River near mouth	10-26-62	0850	1.5	12.8	8.4
North Fork Gunnison River at Hotchkiss	10-25-62	1000	7.5	11.0	8.0
Gunnison River at Austin	10-25-62	1050	9.2	11.0	8.0
Surface Creek or Tongue Fork Creek near mouth	10-25-62	1100	8.8	11.0	8.1
Dallas Creek near mouth	10-25-62	1350	10.5	9.2	7.9
Cow Creek near mouth	10-25-62	1330	11.6	9.2	8.1
Uncompahgre River near Colona	10-25-62	1315	10.0	9.8	8.2
Roubideau Creek near mouth	10-24-62	1720	12.5	9.4	
Escalante Creek near mouth	10-24-62	1650	13.5	9.0	8.1
Gunnison River near mouth	10-23-62	1530	14.0	9.8	7.2
Dolores River near mouth	10-24-62	1140	13.7	8.6	7.8

Activity: Water Quality Management Program for Green Sub-Basin (Reference Summary Item 1, page 8)

Purpose: The water quality management program for the Green Sub-Basin was specifically requested by the Conferees at the January 13, 1960 meeting at Phoenix, Arizona. Six separate portions of the program will be carried out, one for each of the six major Sub-Basins. The purpose is to determine methods for securing the best possible water quality for multiple water use. The programs developed can serve as guides for the conference in progress and other enforcement actions which may be instituted subsequently, and to State and Federal agencies having an interest in the prevention and control of water quality degredation. A more detailed statement of the water quality management program in the Green Sub-Basin will be found in another section.

Summary of Progress:

Only a few studies which relate specifically to the water quality management program for the Green Sub-Basin were carried out. These include the economic base study now in progress and the Price River Basin study for the Corps of Engineers. Many other facets of project work relate to the Green Sub-Basin but also relate to other sub-basins. Examples are the computer analyses of water quality data, preparation of inventories of basic data, hydrologic studies, water quality objectives, etc.

Activity: Studies of the effect on pollution paramenters during a large-scale fish rehabilitation project.

Purpose: In cooperation with state health authorities in Utah and Wyoming, this study evaluated the possible effects of a large-scale fish rehabilitation project on conventional pollution parameters such as coliforms, B.O.D.'s, and bottom animal populations on the Green River.

Summary of Progress:

During September 1962, approximately 450 miles of the Green River in Wyoming and Utah were treated with emulsifiable rotenone for the eradication of undesirable fish populations by the Utah and Wyoming Fish and Game Departments.

Studies conducted during this project made it possible for five domestic water plants to continue operations with a minimum of consumer complaints. Taste, odor, and toxicity were successfully removed with activated carbon. Information developed during this project indicates little or no effect from the toxicant or decaying fish on coliform counts or B.O.D.'s. Bottom animal populations were almost completely eliminated.

A detailed report on this project is being prepared. A summary is attached.

Future Plans:

Fiscal years 1963 and 1964: The only additional work needed on this project is to follow up the recovery of bottom animal populations. This can probably be done with two additional one- or two-day field surveys. This should be done in March or April and again in September or October 1963.

Studies of Pollutional Parameters during the Green River Fish Rehabilitation Project

The Toxicant Operation:

During September 1962, a large-scale fish rehabilitation project was initiated on the Upper Green River by the Wyoming and Utah Fish and Game Departments and the U. S. Fish and Wildlife Service. The purpose of the project was to eliminate, insofar as possible, the undesirable rough fish population in the Green River prior to the closing of Flaming Gorge Dam. The area would later be restocked with desirable game species such as trout which would have a much better opportunity for survival and growth in the new reservoir.

Approximately 450 miles of streams were treated with a fish toxicant during the operation. The reach of the Green River treated extended from above Big Piney, Wyoming, through Wyoming and Utah to the Utah-Colorado border, about 30 miles below Flaming Gorge Dam. The remainder of the meleage consisted of tributaries entering the Green River within this reach.

The toxicant used was an emulsifiable rotenone formulation, Chem-Fish Regular, containing 5% rotenone, a methylated napthalene solvent and an emulsifier. Toxicant application stations were set up at 10-mile intervals throughout the reach of the river. The toxicant was applied through precalibrated valves on hoses stretched across the river at each station. Enough of the formulation was added to maintain a concentration of 5 ppm (formulation) in the river water. Toxicant was applied at each station for a period of seven hours. Application from each downstream station started three hours after the one above had been placed into operation. Thus, a lethal concentration of toxicant was maintained over a long stretch of the river for a considerable period of time. The overlap would prevent the possible escape of any fish from the area. Approximately 22,000 gallons of toxicant were applied over a period of about three days. Over 100 men took part in the operation. Flows in the Green River ranged from about 1,000 - 1,400 cfs during the operation.

No provision was made to collect dead fish. It was believed that they would be scattered sufficiently so as not to create nuisance conditions. The whole area, however, was opened to the general public and they were allowed to collect any number of edible fish desired.

The last toxicant application station was approximately 10 miles above Flaming Gorge Dam. It was expected, however, that a lethal concentration of toxicant would travel much further downstream. In order to prevent destruction of fish in the Dinosaur National Monument, a detoxification station was established near the Colorado-Utah border about 12 miles above the upstream park boundary. At this station, a strong oxidizing agent, potassium permanganate, was used to nullify the effects of the rotenone. This crystalline material was added through grinders and spreaders located on a bridge over the river. Approximately 1,700 pounds of permanganate were added over a two- or three-day period.

Apparently, the whole operation was successful. The kill of fish at all upriver stations was considered essentially complete. Few, if any, fish were killed below the detoxification station.

Problems of Possible Concern:

Some concern was manifested over the possible effects of the toxicant application on other water uses, especially domestic water supplies. The methylated naphthalene solvent was highly odorous and 5 ppm would impart a strong "kerosene" taste and odor to water and thus render it unpalatable. Also, it was expected that large quantities of dead and decaying fish would be present in the river for at least several weeks following the toxicant application.

Five domestic water plants obtained water from the Green River in the reach to which the toxicant was applied. As no alternative water supplies and a minimum of storage capacity were available, it would be necessary to use water from the river during most of the toxicant operation. The water plants concerned were: Fontinelle Camp, Wyoming, operated by the U. S. Bureau of Reclamation, with a population of about 400; Stauffer and Intermountain Chemical Companies each with about 400 to 500 employees and additional use of considerable water for industrial uses; Green River, Wyoming, which also furnished water to Rock Springs, Wyoming, total population of about 15,000, operated by the Pacific Power and Light Company; Dutch John, Utah, operated by the Arch Dam Construction Company for the U. S. Bureau of Reclamation, with a population of about 1,200. With the exception of Fontinelle Camp, all of these plants had complete treatment facilities. Fontinelle had provision for chlorination only and about two days' storage.

Two water users downstream from the area of toxicant application may also be affected. These are the California Oil Company which obtained water at Red Wash, Utah, and the town of Green River, Utah, with a population of 1,000, located some 200 miles further downstream. Both of these plants had complete treatment facilities.

The Public Health Service had recently conducted research and field studies on a similar toxicant operation. These studies showed that toxicity, tastes, and odors could successfully be removed from water with activated carbon.

Colorado River Project personnel were requested to participate in the toxicant operation and to assist water plant operators in producing a palatable water. It was also felt that this was an opportune time to study the effects of the fish toxicant application on certain pollution parameters. No knowledge was available as to what effects may be produced either from the toxicant or from the large tonnage of decaying fish on such parameters as coliform count or B.O.D. Also, little was known concerning the effect of bottom macroinvertebrates which are often used as a measure of pollution.

Protection of Water Supplies:

Field laboratories were set up in Green River, Wyoming and Dutch John, Utah, water plants. Their major purpose was to determine the toxicant concentration in the raw waters, to estimate the amounts of carbon needed to remove toxicity, tastes and odor, and to check the finished water for palatability. Other determinations would be made as time permitted. The State Health Departments assisted in collecting samples from other water plants and in conducting some of the analyses.

As no satisfactory chemical method of analysis for rotenone was available, analyses were made by a bioassay technique using fingerling trout furnished by State Fish and Game Departments. Ten trout were subjected to a series of concentrations of the rotenone formulation in Green River water. A standard curve was plotted on logarithmic paper, relating time of fish reaction (loss of equilibrium or mortality) to concentration. By timing fish reaction in unknown samples and using this curve, the toxicant concentration of any sample could be estimated. It was, however, necessary to conduct all tests at the same temperature (16°C.) or to prepare known curves for different temperatures to produce valid results.

Laboratory tests were conducted to determine the amount of carbon needed to remove toxicity, taste, and odor from water containing specific concentrations of the rotenone formulation. Varying amounts of carbon (Aqua-nuclear, powdered) were added to waters containing a fixed amount of formulation. It was found that 150 ppm of carbon would remove 5 ppm of toxicant formulation. By using a straight-line arithmetic plot, the amount of carbon needed to remove any quantity of formulation could be estimated. Threshold odor determinations indicated that tastes and odors were also removed by this amount of carbon.

Raw water samples from the water plants were analyzed for toxicant concentration. Based on the analyses, the amounts of carbon needed were estimated from the prepared curve. The necessary amounts of carbon were added at fixed intervals to the water supply, usually through one of the chemical feeders. Samples of finished water were assayed for toxicity and threshold odor to determine the effectiveness of the carbon treatment.

The above procedure was carried out on raw and finished water samples for a four- or five-day period until the toxicant had naturally dissipated. The operations were successful in that few consumer complaints were received. Expected odors from dead fish did not materialize. Apparently, the dead fish were well scattered throughout the treatment area with no accumulation sufficient to produce an odor in the water.

Effect on Pollution Parameters:

MF coliform determinations were made during the toxicant operation at the laboratory in the Green River, Wyoming, water plant. No effect on coliform counts was observed that could be attributed to the toxicant operation.

The Utah Health Department conducted coliform, B.O.D., and other water quality determinations on river samples from Dutch John, Jensen, and Red Wash, Utah. Four sets of samples were collected, the first before the operation and the remainder at weekly intervals following the toxicant application. Little, if any, definite effect on pollution parameters was apparent. However, a few coliform counts and some manganese concentrations were higher following the toxicant operation.

Coliform, threshold odor, B.O.D., and manganese determinations were made on river samples collected at Green River, Utah, several hundred miles downstream from the treated area. These determinations were made several times daily for a week following the estimated arrival time of waters from the area in which the toxicant was applied. No effects on these parameters were indicated. A heavy rainstorm in the area was believed to be the cause of some increase in coliform counts and manganese concentrations towards the latter part of the survey period.

Bottom animal samples were collected at five river stations before and after the toxicant application. Although good populations of clean-water animals were found before the operation, the bottom animal population was almost completely destroyed by the toxicant. Follow-up studies are needed to determine the extent and time of recovery of these populations.

Activity: Study of Salinity in the Colorado River System

Purpose: The overall salinity study has four broad objectives:

1. To ascertain present and probable future levels of salinity in surface waters throughout the Colorado River Basin.

2. To identify present and probable future major sources of salinity.

3. To determine the present and probable future physical and economic significance of salinity in surface waters.

4. To recommend various measures and/or approaches whereby salinity sources can be controlled.

Accomplishments:

FY 1963 to date. Salinity is one of the largest single contributors to pollution of waters in the Colorado River system. Long-term water quality data collected by the U. S. Geological Survey at various sampling points in the Colorado River Basin show that levels of salinity are above desirable limits for many legitimate water uses. In addition, personnel from the Colorado River Basin Project have collected chemical data in a number of areas in the Basin. High concentrations of salinity were noted in almost all cases. The most severe situation was noted in the Yuma, Arizona area where it became necessary to abandon the Colorado River as a source of domestic water supply. A further indication of the salinity problem in Colorado River waters is the Mexican charge that extensive crop damages have resulted from using this water for irrigation. The three conferences on the matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries have strongly emphasized the need for evaluation of the salinity problem with an aim to suggesting means of controlling this source of pollution.

Accomplishments to date have been limited primarily to the collection of background data and the formulation of a large scale study proposal. These include:

1. A research proposal for evaluating return irrigation flows as a source of in-stream salinity was submitted to the PHS Taft Engineering Center in March 1962.

2. A continuing study of the salinity problem at Yuma, Arizona is underway. One report has been released and one additional report is in preparation.

Activity: Salinity in the Colorado River System (continued)

3. A two-stage study of salinity in irrigation return flows in the Grand Junction, Colorado area was carried out in 1962; a report on this study effort is in preparation.

4. An intensive two-week field study of present salinity in the Gunnison River Basin was carried out during the peak irrigation period of 1962.

5. By use of a rapid data computer, USGS water quality data are being analyzed in order to determine trends in salinity levels in the Colorado River system over the period of record.

6. Detailed maps of irrigated lands in the Colorado River Basin in 1959 are under preparation, on a reimbursement agreement basis, by the Economic Research Service of the U. S. Department of Agriculture.

7. A water quality network was established in the Upper Main-Stem Sub-Basin to obtain supplemental salinity data on a seasonal basis.

8. Data from the 1959 Census of Irrigation, by major crops grown, have been summarized by counties and sub-basins.

9. A planning meeting was held with Dr. William McDaniel, University of New Mexico and Dr. Allen Kneese, Resources For The Future, Inc. in November 1962 in order to establish liaison for coordinating the Project's salinity study with the proposed RFF/New Mexico University study of salinity in the Colorado River Basin. Informal discussions in regard to the Colorado River salinity problem have also been held with Dr. Robert Whitney, Chairman, Department of Agronomy at Colorado State University, Dr. Maurice Kelso, Professor of Agricultural Economics at the University of Arizona and Mr. Kirk Sandals, Southwest River Basin Representative, U. S. Department of Agriculture.

10. A bibliography of technical reports which deal with irrigation is presently under preparation.

11. A list of potential salinity consultants has been compiled.

State WPC people should be principal consultants

12. A series of planning meetings for formulating the salinity study have been held at the Project level.

Activity: Salinity in the Colorado River System (continued)

Balance of 1963.

1. Complete evaluation of available basic data for determination of historical trends in salinity levels in the surface waters of the Colorado River Basin.

The major source of data will be the long-term water quality data available from USGS. Supplemental sources of data, including results from the Project's Upper Main-Stem Water Quality Network, a series of short-term field studies, and other available data, will also be utilized. Preparation of a progress report covering this phase of the study will be initiated.

2. Establish contact with Federal, State and local agencies having an interest in salinity in the Colorado River System for the purpose of securing existing data and avoiding duplication in field activities. These include:

   a. USDA Salinity Laboratories at Riverside, California and Tempe, Arizona

   b. U. S. Geological Survey and Bureau of Reclamation of the U. S. Department of Interior

   c. Soil Conservation Service and Economic Research Service of the U. S. Department of Agriculture

   d. Various State agencies

   e. Local interest groups

3. Green and Upper Main-Stem Sub-Basins

   Plan program to identify sources of salinity.

4. Complete final work plans for FY 1964, following the determination of salinity levels in the Colorado River System on a broad basis and after review of the results of this study phase with various salinity specialists.

Activity: Study of Salinity in the Colorado River Basin (continued)

Long-range Plans:

1. Steps will be taken to complete objective (1) listed above to a satisfactory degree of detail.

As a minimum, salinity levels should be determined at the junction of all major tributaries and the mainstem of the Colorado River. In addition, however, salinity levels at interstate stream points and significant intrastate stream points would be desirable. Historical trend data, relation to hydrologic variations, will be evaluated to serve as a base for projecting probable future salinity levels. This phase of the study will entail considerable office work and additional field investigations.

2. Determination of major sources of salinity and their location will proceed concurrently with the completion of item (1) listed above.

Analysis of changes in salinity levels at various points in the river system may indicate the need for the establishment of a number of short-term sampling stations. Initial efforts will be limited to the Green River and Upper Main-Stem Sub-Basins so that data will be developed early enough to be incorporated into the water quality management program reports for these two sub-basins. This phase of the study will require personnel skilled in geology, soils and irrigation--much of this talent may have to be obtained through contract and/or consulting arrangements.

3. Investigation of methodology for projecting salinity levels at various points in the river system under a variety of assumed future conditions will have to be initiated at an early date.

This effort will require personnel skilled in hydro-geology, econometrics, agronomy and allied fields. It is anticipated that much valuable assistance can be obtained from the University of New Mexico study of salinity in the Colorado River.

4. The determination of present and future physical and economic significance of various levels of salinity throughout the Colorado River Basin will have to precede the "corrective action" suggestion phase.

For example, at the present time it appears more important to correct the salinity problem in some areas of the basin than in others.

Activity: Study of Salinity in the Colorado River System (continued)

5. The suggestions of "corrective action" phase become the end product of the overall salinity study. As problem areas are identified, recommendations for corrective action will be developed.

In practice, however, efforts on this phase of the study will be carried out concurrently with the other study phases. It will perhaps be the most difficult aspect of the study because of the rapidly changing technology in this field of endeavor.

Activity: Identification of principal sources of salinity in the Upper Main-Stem and Green Sub-Basins.

Purpose: Development of field data and other necessary information in the Upper Main-Stem and Green Sub-Basins as a part of the overall study of salinity in the Colorado River Basin.

Summary of Progress:

1. A two-stage study of salinity in the Grand Junction, Colorado area was undertaken during February and August, 1962. Samples were collected both during irrigation and non-irrigation seasons to determine salinity contributions from land irrigation and other sources. Analysis of this data is in the initial phases. A report will be issued during FY 1964.

2. An intensive two-week field study of water quality conditions in the Gunnison River Basin was undertaken in August of 1962. This study coincided with the period of peak irrigation in the Gunnison River Basin and will provide data on contributions of salinity to surface supplies from irrigation and other sources. Analysis of this data is in the initial phases. A report will be issued during FY 1964.

3. A water quality network consisting of 42 stations sampled on a once-a-month basis was initiated in July, 1962, for important streams of the Upper Main-Stem Sub-Basin. The data to be obtained by this network is intended to supplement the long-term USGS water quality data in relation to salinity conditions of surface waters within this sub-basin. Analysis of this water quality data has not been started.

4. Office work has been initiated on further analysis of USGS long-term water quality data from the Project's first stage IBM computer run to provide background data on sources and magnitudes of salinity.

5. Data on irrigated lands within the Basin have been summarized by counties and sub-basins as derived from the 1959 Census of Irrigation.

Future Plans:

Available background data will be collected and analyzed. The advice and consultation of experts principally with the U. S. Department of Agriculture and with Western

Activity: Identification of principal sources of salinity in the Upper Main-Stem and Green Sub-Basins. (continued)

universities who have undertaken studies of salinity as it relates to water quality will be solicited by the Project. The full-scale salinity program to be developed in the near future will consider the initial field activities to be carried out in the Green and Upper Main-Stem Sub-Basins. Details will be given on the number, type, and duration of sampling stations to be employed in the Green and Upper Main-Stem Sub-Basins. It is anticipated that field data on quality of surface waters will be collected at a number of locations on each main river and at a minimum of one location on each important tributary stream.

The Upper Main-Stem and Green Sub-Basins will receive continued attention in FY 1964 in regard to the field investigations to be undertaken for delineating sources and magnitude of salinity contributions. The field planning, briefly described above, will be put into operation, and further implementation and modification of sampling networks will be made according to indicated needs. Field surveys in FY 1964, generally of limited duration, will be conducted to pinpoint sources and quantities of salinity contributions. The preliminary data collection and analyses will be directed toward segregation of general areas of high, intermediate or low salinity contribution. Subsequent field studies will provide specific data on pinpointing and accurate measurement of singular sources of salinity contributions.

Activity: Interstate Stream Pollution Studies

Purpose: Study of the Water Quality in Interstate Streams of the Colorado River Basin to define the type of pollution problems that may exist.

Summary of Progress:

Summary reports concerning the quality of interstate waters are prepared by the various Regional Offices under an existing program. The PHS Regional Offices of Region VII, VIII and IX have undertaken study of waters of the Colorado River Basin. These reports give major attention to municipal and industrial wastes and their effect on water uses. Much of this information is obtained from State Water Pollution Control Agencies when it is available. In most cases, the Regional Offices and the various States do not have adequate laboratory facilities and support and therefore water quality data for these streams is limited. In some cases, the Project has furnished analytical results to the Regional Offices. The latter information has filled important gaps encountered in preparation of Summary Reports.

The problem of salinity is not covered adequately by Summary Reports. The Project is giving major emphasis to the evaluation of salinity within the Basin. These salinity studies will give important data in the area of interstate waters.

The first step in the program of interstate stream pollution studies as undertaken by the Project is to conduct meetings between the Project and each of the PHS Regional Offices of Regions VII, VIII, and IX. The objectives of these meetings are to (1) discuss the existence and interchange of interstate stream water quality data; (2) establish priorities of study for interstate streams within the Basin; and (3) discuss assistance that the Regional Offices can provide on necessary field investigations.

A meeting was conducted with Region VIII in November, 1962. A coordinated approach of activities toward interstate stream studies was developed at that time. The Project and the Regional Office will cooperatively determine the sufficiency of current information available for particular streams and a priority of study for streams will be established by the Project. If a probable interstate pollution problem is indicated from the evaluation of available data, a reconnaissance or short-term field survey will be undertaken. In the event that a further study or full-scale investigation

Activity: Interstate Stream Pollution Studies (continued)

is required, this will be conducted by the Project with assistance from the Regional Office. Joint cooperation between the Project and the Regional Office will aid the Project in its efforts to assess quality of interstate streams and aid the Regional Offices in their preparation of Summary Reports.

Future Plans:

The Project in the very near future plans to undertake meetings with the PHS Regional Offices of Regions VII and IX to develop a cooperative plan on study of quality of interstate waters. It is anticipated that an approach similar to that developed with Region VIII will be suitable to Regions VII and IX. The Project will soon thereafter initiate its detailed study program in cooperation with the Regional Offices and the various Basin States.

Activity: Ground Water Studies in the Vicinity of Uranium Mills

Purpose: These studies were conducted to determine potential or existing contamination by uranium milling activities of ground water beds containing potable waters, and non-potable aquifers that discharge to nearby surface streams.

Summary of Progress:

Reconnaissance surveys of conditions at all uranium mill sites within the Basin were conducted with the exception of the Tuba City, Arizona mill. (This mill was omitted from consideration as a source of ground water contaminants because of its location and the nature of its milling process.) A report of these studies has been prepared in draft form for review.

Some of the more important preliminary findings from these studies are given as follows:

1. The raffinate lagoons of the Vanadium Corporation of America mill at Durango, Colorado overlie permeable strata containing currently used ground water. There is no evidence at this time of leakage from these lagoons to the underlying aquifers.

2. At the Kerr-McGee mill in Shiprock, New Mexico, there is no aquifer of potable water underlying the raffinate lagoons and tailings pile. However seepage from the lagoons and tailings areas flows in alluvium overlying the impervious Mancos shale formation laterally to seeps on the south bank of the San Juan River. Samples of seepage from two discharge points along the south bank of the San Juan River yielded results of 3.8 and 0.59 $\mu\mu g/l$ of radium-226. Seepage discharge is above the points of intake of Shiprock, New Mexico and the Navajo Helium Plant. Further study and evaluation will be necessary to determine if any contamination of these domestic supplies is present from chemical waste discharges originating from the uranium mill.

3. At the Texas-Zinc Co. uranium mill at Mexican Hat, Utah, a small amount of downward seepage from the raffinate lagoon and tailings pile enters a highly-fractured limestone strata and flows laterally to discharge points in Gypsum Wash. The confluence of Gypsum Wash with the San Juan River is a short distance above the intake point of the uranium mill and town of Mexican Hat, Utah water supply on the San Juan River.

The limestone strata is not a source of potable ground water.

Activity: Ground Water Studies in the Vicinity of Uranium Mills (cont.)

4. Leached constituents from the large tailings area at the Vanadium Corporation of America upgrading uranium mill at Vancorum, Colorado enter the San Miguel River during periods of surface runoff. This may represent a potential contamination of ground waters because the San Miguel River is a recharge agent for aquifers utilized for domestic supply downstream at Uravan, Colorado. One of the aquifer recharge areas is located about halfway between Vancorum and Uravan, Colorado. The aquifer is also recharged by downward percolation from the entire area.

5. At the Kerr-McGee mill in Gunnison, Colorado (now abandoned) there is no evidence of contamination in the potable ground water utilized from the alluvium underlying the vicinity of the mill. Two samples of ground water from near the mill yielded identical results of 0.01 μμc/l of Ra-226. No trace of arsenic was found which was present in the raw ore processed by the mill.

Future Plans:

A final report including recommendations for future work will be issued about March 1, 1963.

Ground water samples will probably be taken for minerological and radiological content in connection with follow-up surveys in the Uravan, Colorado and Monticello, Utah study areas this year.

Activity: Investigation of Aggregate Future Water Demand for the Price River Basin.

Purpose: This is a study of the aggregate water demand for the Price River Basin to help in the planning of multiple-purpose water storage and flood control projects.

Summary of Progress:

Carried out field work in the Basin and analyzed published data for a preliminary report which was finished in November. Also discussed the report with State and Federal officials in Utah.

Future Plans:

The report will be summarized and analysis of the most probable growth path will be included. This report will then be submitted to the Corps of Engineers, following Headquarters approval.

Activity: Stream Flow Regulation Studies

Purpose: To provide the Bureau of Reclamation and Corps of Engineers with information on the need for and value of storage in proposed reservoirs for the purpose of water quality control. This is in accordance with section 2b of Public Law 660, as amended by Public Law 87-88. A copy of the law is attached.

Summary of Progress:

Stream flow regulation studies have been carried out by the Water Quality Management Program, with economic assistance from the Economic Studies personnel. Reports have been completed for the following projects in the Colorado River Basin since July 1962:

Project	Location	Agency
Alamo Reservoir	Arizona	Corps of Engineers
Bridge Canyon	Arizona	Bureau of Reclamation
Dolores	Colorado	Bureau of Reclamation
Fruitland Mesa	Colorado	Bureau of Reclamation
Lyman	Wyoming	Bureau of Reclamation
Marble Canyon	Arizona-Utah	Bureau of Reclamation
Senator Wash	California-Arizona	Bureau of Reclamation

In addition, a short term survey was made in early October 1962 of the Dallas Creek Project area near Ridgeway, Colorado. Water and biological samples were obtained at a number of locations. Although laboratory analyses are not yet available, preliminary indications show that considerable acid mine drainage flows from a tributary of the Uncompahgre River. The acid dissolves heavy metals resulting in toxicity in the stream.

Future Plans:

During the balance of Fiscal Year 1963 reports will be written for the following projects in the Colorado River Basin:

Project	Location	Agency	Degree of Completion
Southern Nevada	Nevada	Bureau of Reclamation	Completed
Dallas Creek	Colorado	Bureau of Reclamation	Initiated
San Miguel	Colorado	Bureau of Reclamation	Initiated
Jensen Unit-Cen. Utah	Utah	Bureau of Reclamation	Initiated
Upalco Unit-Cen. Utah	Utah	Bureau of Reclamation	Initiated
Upper Gila	Ariz.-N. Mexico	Bureau of Reclamation	Initiated
San Pedro	Arizona	Bureau of Reclamation	Initiated
Maxwell	Arizona	Bureau of Reclamation	Initiated

Activity: Stream Flow Regulation Studies (continued)

Work during Fiscal Year 1964:

Project	Location	Agency	Degree of Completion
Upper Gila River	Ariz.-N. Mex.	Bureau of Reclamation	Completed
Jensen Unit-Cen. Utah	Utah	Bureau of Reclamation	Completed
Upalco Unit-Cen. Utah	Utah	Bureau of Reclamation	Completed
Dallas Creek	Colorado	Bureau of Reclamation	Completed
Gray Canyon	Utah	Bureau of Reclamation	Completed
San Miguel	Colorado	Bureau of Reclamation	Completed
West Divide	Colorado	Bureau of Reclamation	Completed
Battlement Mesa	Colorado	Bureau of Reclamation	Initiated
Maxwell	Arizona	Bureau of Reclamation	Initiated
San Pedro	Arizona	Bureau of Reclamation	Initiated
Basalt	Colorado	Bureau of Reclamation	Initiated
Bluestone	Colorado	Bureau of Reclamation	Initiated
Yellow Jacket	Colorado	Bureau of Reclamation	Initiated
Central Arizona	Arizona	Bureau of Reclamation	Initiated